New Scientist

WEEKLY 28 May 2022

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Podcast

Weekly

This week, the team look at solutions to the global food crisis, which has been brought on by a mix of the coronavirus pandemic, intensifying climate change and the war in Ukraine. They also discuss a new field of study called "ecoacoustics", which is being used to assess biodiversity, sharing sounds of an "animal orchestra" recorded in the Brazilian rainforest. Plus, find out why some word pairings are funnier than others – "spam scrotum" anyone?

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Life in the clouds Discover the secrets of the Incas at Machu Picchu

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Kids and covid-19 Will parents want the jab for their under-5s?

Video

Wait in line

Have you ever seen a pod of dolphins queuing? These intelligent aquatic mammals have recently been spotted waiting patiently for their turn to rub themselves against corals and sea sponges, which contain a number of compounds with antibacterial and antioxidative properties. It is thought they could be treating their wounds and skin diseases.

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Newsletter

Health Check

Reporter Clare Wilson has been looking into new covid-19 vaccine roll-outs for young children. A jab for under-5s may become available in the US later this year, but it is unclear when it will reach the UK and the rest of Europe. What impact will it have, and will people actually want it?

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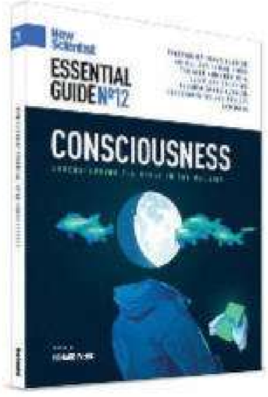
Podcast

> **"Word pairs like 'playboy parrot' and 'gnome bone' came out on top"**



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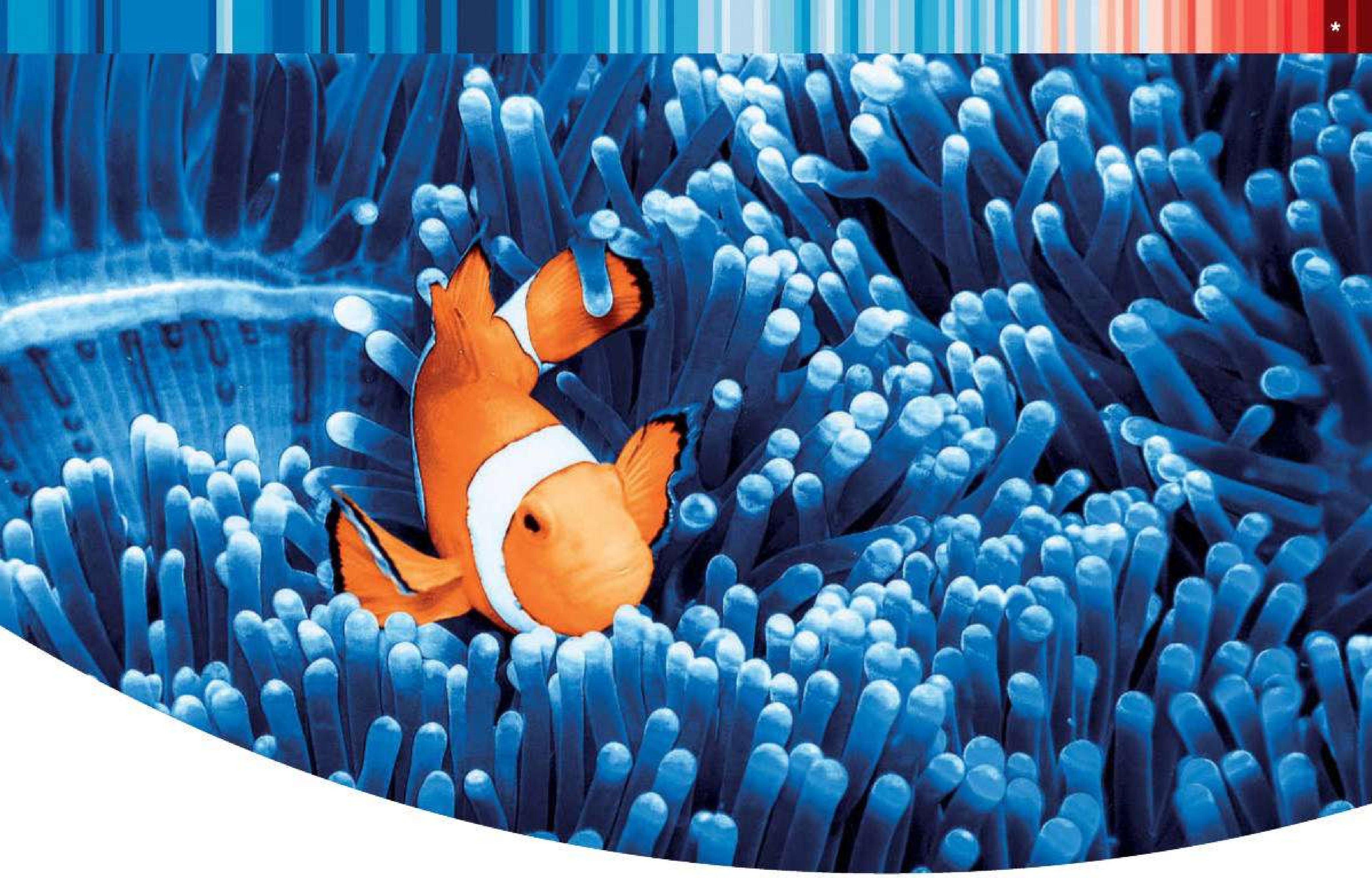

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AN IMPORTANT MESSAGE FROM PROFESSOR NICK LEMOINE CBE MD PHD FMEDSCI, CHAIR OF THE MEDICAL RESEARCH FOUNDATION

Gifts in Wills could be the key to protecting the future of human health

Our experience of COVID-19 shows how suddenly a global health challenge can appear. As someone interested in science, you will understand that while nobody can predict what we will face next, we can be certain that the future will bring many more threats to human health.

As Chair of the Medical Research Foundation – the charitable arm of the Medical Research Council – I have seen the incredible impact that individuals who remember the Foundation in their Wills can have on the future of our health and wellbeing here in the UK. These gifts fund research and researchers which can have far-reaching implications for human health.

With a gift in your Will you can play a key role in providing the science that will protect the health of future generations.

Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

Without support at the crucial early stages, researchers like Dr Kaforou can be forced to abandon their passion and leave science altogether, with an immeasurable loss to future human health. Gifts in Wills provide the long term funding and security that allows the Foundation to invest in projects like Dr Kaforou's and lay the foundations for quality research in years to come.

Your Will can fund the rational response to health challenges that medical science provides.

> **"As scientists, our duty is to secure the future of research for the generations that follow."**
>
> Professor Fiona Watt, Patron of the Medical Research Foundation and Director of the European Molecular Biology Organization.

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"The funding I received through the Medical Research Foundation will be transformative for my research." Dr Myrsini Kaforou

While we don't know what the future holds for human health in the UK, we do know that research, and the brilliant scientists driving that research forward, are the key to meeting those challenges for years to come.

But many of these scientists rely on the generosity and foresight of fellow members of the public – people like you, who understand the power of science and are willing to leave a gift to medical research in their Wills. At the Medical Research Foundation, over 90% of our voluntary income comes from individuals who choose to include a gift in their Will – they are crucial in the Foundation's ability to fund research that will enable the next generation of scientists to make real world discoveries in the future.

I firmly believe that a gift in your Will to the Medical Research Foundation is an excellent investment and will have a lasting impact on science and on the future of human health in the UK.

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Professor Nick Lemoine CBE MD PhD FMedSci
Chair of the Medical Research Foundation

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The nuclear question

Nuclear power's promise remains elusive, and a massive issue remains: who pays?

ON PAPER, nuclear power is a brilliant way to tackle climate change. Yet the reality of this technology, which promises a steady supply of low-carbon power to cope with wind-free days, frequently disappoints, as Michael Brooks reports on page 38.

Take the news that the UK's first new nuclear power station in a generation may be two years late and cost up to £8 billion extra. This is the third time since the plant was first approved in 2016 that the budget and schedule for Hinkley Point C have been revised by EDF Energy, the French state-owned firm leading its construction.

The delay doesn't mean that lights will go out, nor missed carbon targets. But it does hold consequences for future nuclear projects, in the UK and around the world. It shows that UK prime minister Boris Johnson's recent nuclear power rhetoric, including his pledge to build a new nuclear plant every year, will be hard to deliver on. It also brings up the question that always bedevils nuclear: who pays?

Hinkley's cost overrun will be borne by EDF, the downside to its upside of lucrative government subsidies when the reactor starts generating power. Yet a new model for funding nuclear plants, set to be agreed imminently by the UK and EDF, would see consumers paying more via their energy bills if construction budgets balloon.

> "Societies need to have an honest conversation about paying for the benefits of nuclear power"

Nuclear power could yet play a big role in decarbonising electricity grids outside China, the only country building new reactors at a serious rate. For that to happen, though, societies need to have an honest conversation about whether they are willing to pay for its benefits.

They also need to weigh up what is lost by supporting nuclear. Last month's UK energy strategy offered nothing new on solar power or energy efficiency: low-cost, low-carbon options that can be deployed now, not years in the future. What's more, wind farms have the UK on course to become a net electricity exporter by 2030, as we report on page 12. Nuclear money could be spent on even more wind.

Nuclear power advocates have been overpromising for almost seven decades, ever since the 1950s claim that it would be "too cheap to meter". Nuclear can be part of our race to net zero, but cool heads are needed to assess its true costs. ▮

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Net Zero Strategy The UK expects to be a net electricity exporter by 2030 **p12**

Taste of friendship Bottlenose dolphins recognise each other's urine **p15**

Tree mixtures Plantations with diverse species grow better **p16**

REUTERS/DENIS BALIBOUSE

A meeting of world health representatives in Geneva on 22 May

Diseases

Monkeypox on the rise

Reported cases are growing rapidly in the largest known outbreak outside of Central and West Africa, reports **Jason Arunn Murugesu**

AS *New Scientist* went to press, 172 monkeypox cases had been confirmed in North and South America, Australia, the Middle East, North Africa and across Europe, according to a list of reports compiled by Moritz Kraemer at the University of Oxford, John Brownstein at Boston Children's Hospital in Massachusetts and their colleagues.

These same regions also have a total of 87 suspected cases of monkeypox and 27 people hospitalised with the infection. As of 23 May, the UK had recorded 57 cases of the virus, and it appears to be one of the hardest-hit countries so far. No related deaths have been reported anywhere, according to the World Health Organization (WHO).

In the past, outbreaks outside of Central and West Africa have usually been linked with travel to those regions, where the virus is endemic. A small 2021 outbreak in the UK occurred after someone travelled from Nigeria to Manchester. In 2003, monkeypox entered the US after exotic pets including mice and squirrels were imported from Ghana.

The current outbreak is unusual in that infections seem to be mostly spreading between people with no recent travel links to affected regions of Africa, suggesting the virus is being transmitted undetected in the community. In the UK, early cases were largely seen in gay men, bisexual men or men who have sex with men. This is the first time cases with no travel history have been reported in Europe, according to the European Centre for Disease Prevention and Control (ECDC).

Monkeypox is usually mild, with most cases resolving within a few weeks without treatment. Bulletins from organisations like the WHO, the US Centers for Disease Control and Prevention (CDC) and the UK Health Security Agency (UKHSA) mean countries are actively looking for infections, which has probably caused instances to be identified that would otherwise have slipped under the radar.

> "Early monkeypox symptoms include fever, headache and muscle aches"

Nevertheless, monkeypox cases are expected to rise, at least in Europe, over the coming months. "As we enter the summer season in the European region, with mass gatherings, festivals and parties, I am concerned that transmission could accelerate, as the cases currently being detected are among those engaging in sexual activity, and the symptoms are unfamiliar to many," the WHO's regional director for Europe, Hans Kluge, said in a statement. Early symptoms include fever, headache and muscle aches, sometimes followed by a chicken-pox-like rash that causes scabs.

Monkeypox isn't considered a sexually transmitted infection, but can spread via skin-to-skin contact or sharing bedding with an infected person.

"We would recommend to anyone who is having changes in sex partners regularly, or having close contact with individuals that they don't know, to come forward if they develop a rash," Susan Hopkins, the UKHSA's chief medical adviser, told the BBC.

In the UK, close contacts of those infected with monkeypox are being advised to isolate for 21 days by the UKHSA and are being offered a smallpox vaccine, which is 85 per cent effective at preventing a monkeypox infection. According to Politico, 1000 doses of the vaccine have already been administered in the UK, with 3500 doses left.

In the US, the CDC is advising people with monkeypox to isolate, while the ECDC has urged European countries to prepare infection-control strategies, such as increasing contact tracing and readying vaccines. ■

Turn to page 8 for more on monkeypox.

Viruses

Monkeypox: Key questions answered

Cases are rising worldwide, leaving some people anxious that the virus could evolve into a pandemic alongside covid-19. **Michael Le Page** addresses monkeypox's risks

WITH monkeypox cases appearing globally (see page 7), some with no obvious source of infection, it seems the virus may be spreading undetected. While not as serious a disease as covid-19, it is understandable that some people feel a sense of familiarity with the early days of the coronavirus pandemic. Here are the key facts you need to know as the outbreak unfolds.

What is monkeypox?

Monkeypox is a disease caused by a virus that, as the name suggests, usually spreads among monkeys in Central and West Africa, but occasionally jumps to people.

It was first spotted in monkeys in labs in 1958. The first human case was identified in what is now the Democratic Republic of the Congo in 1970.

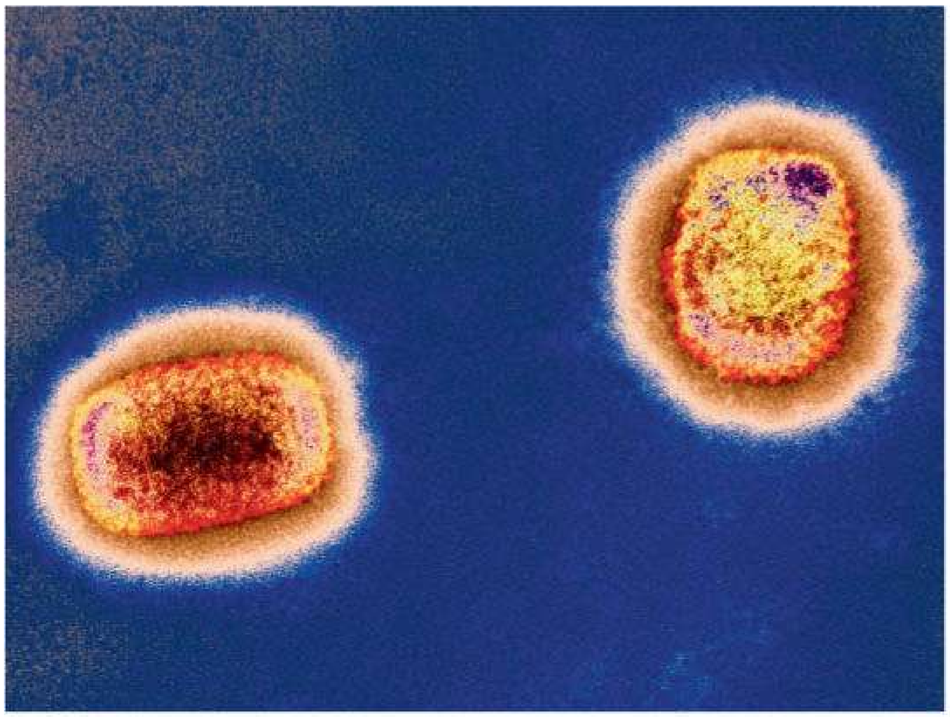
How does it spread?

According to the World Health Organization (WHO), "monkeypox can be transmitted by droplet exposure via exhaled large droplets and by contact with infected skin lesions or contaminated materials". Some might interpret this as meaning the virus is airborne, but the WHO doesn't use this term.

The US Centers for Disease Control and Prevention (CDC) states: "Human-to-human transmission is thought to occur primarily through large respiratory droplets. Respiratory droplets generally cannot travel more than a few feet, so prolonged face-to-face contact is required."

But the virus doesn't usually spread easily between people, with the UK Health Security Agency (UKHSA) saying the risk to the UK population amid the ongoing outbreak "remains low".

Monkeypox can also spread via contact with clothing or bedding used by an infected person.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Monkeypox virus particles captured via a coloured transmission electron micrograph

It isn't regarded as a sexually transmitted infection, but it can be passed on during sex via skin-to-skin contact, says the UKHSA.

What are the symptoms?

The first symptoms of monkeypox include fever, headache, muscle aches, backache, swollen lymph nodes, chills and exhaustion, says the UKHSA.

A rash can also develop, typically on the face first and then on other parts of the body, including the genitals. The rash can look like chickenpox, before forming scabs.

1958

The year monkeypox was first identified in monkeys

1 in 100

The death rate of the West African monkeypox strain in known cases

170+

The number of confirmed or suspected cases worldwide so far

How deadly is it?

Monkeypox is usually mild, with most people recovering within a few weeks without treatment.

In Africa, monkeypox can be deadly in as many as 1 in 10 people who contract the disease, according to the CDC. However, there are two main types of monkeypox: the Congo strain and the West African strain. The WHO states that the 1 in 10 figure applies to the Congo strain and the West African strain is deadly in around 1 in 100 reported cases.

Amid the ongoing outbreak, only the West African strain has been identified in the UK. This information isn't yet available for all of the other affected countries.

What's more, the WHO says these figures refer to the proportion of deaths in those confirmed to be infected, called the case fatality ratio. But with diseases whose symptoms can be mild, many cases go undetected, meaning the infection fatality ratio – the proportion of deaths among all those infected – can be substantially lower.

According to the WHO, children with monkeypox are more likely than adults to become seriously ill. Becoming infected during pregnancy can also lead to complications, including stillbirth.

Are there any treatments or vaccines?

Yes. The antiviral drug tecovirimat (also sold as Tpoxx) is approved in most of Europe for treating monkeypox, smallpox and cowpox. It is only approved for smallpox in the US. In animal studies, tecovirimat significantly increased the survival rate of animals given very high doses of monkeypox.

There is also a vaccine called Jynneos (also known as Imvanex and Imvamune), which is approved in the US and most of Europe for preventing monkeypox and smallpox in people aged over 18.

> "It's important not to put this on the same levels as a novel coronavirus"

In addition, those who are old enough to have been vaccinated against smallpox as babies should have some protection. Routine smallpox vaccination ended in the UK in 1971 and in the US in 1972.

Have there been outbreaks outside Central and West Africa before?

There have been several monkeypox outbreaks outside these regions, but usually involving only a handful of cases with very limited local spread. In 2018, a person arriving from Nigeria spread the virus to two people in the UK. In 2021, the UK reported three cases in one household, one member of which had travelled to Nigeria.

This week, it was revealed that one of these 2021 cases was treated with tecovirimat. This may have shortened the duration of their illness, as their viral load fell immediately after treatment began (*The Lancet Infectious Diseases*, DOI: 10.1016/S1473-3099(22)00228-6).

Could this outbreak be caused by a new strain of monkeypox?

That remains unknown. The fact that so many cases are being reported in several countries certainly suggests this strain is more transmissible than others. But chance events can help a virus spread more widely, such as being carried by a "superspreader".

A team in Portugal has released a draft genome of the virus behind the ongoing outbreak, confirming it is the West African variant and most closely related to the virus responsible for much smaller outbreaks in the UK, Singapore and Israel in 2018 and 2019.

It is unclear whether this virus has mutated to become more transmissible. Viral sequencing is ongoing, but establishing whether the circulating virus is unique won't be easy, given its large and complex genome.

Could this become another pandemic?

The expectation is this outbreak can be contained by contact tracing. The UK is offering vaccines to contacts regarded as being at high risk of infection. While researchers aren't totally ruling out a pandemic, they don't think it is at all likely. "I don't think the science points to that at this moment," says John Brownstein at Boston Children's Hospital. "It's important not to put this on the same level as a novel coronavirus." ▮

Politics

Australia votes for climate action in 'greenslide' election

Alice Klein

AUSTRALIA'S election on 21 May has been described as a "greenslide" after voters abandoned the long-standing, pro-coal, Liberal-National Coalition government in droves in favour of candidates that support stronger action on climate change.

The Labor party, which promised to do more to tackle climate change, has won the most seats overall. Its leader, Anthony Albanese, was sworn in as prime minister on 23 May.

But the big surprise was the record number of seats snatched from both major parties by the Australian Greens party and several independents who advocate more ambitious climate action.

Votes were still being counted as *New Scientist* went to press, with Labor looking likely to form a majority in the House of Representatives on its own. The Greens party looks set to win three out of 151 seats in the House of Representatives and 12 of 76 Senate seats – its best result ever. Another nine House of Representatives seats have been won by independent candidates dubbed the "teal independents" because of their shared climate focus.

Greens supporters celebrate in Brisbane, Australia

DAN PELED/GETTY IMAGES

If Labor falls short of a majority after counting is complete, the Greens and teal independents could hold the balance of power in parliament.

Greens leader Adam Bandt called the result a "greenslide" and said that the people of Australia, where voting is compulsory, have "delivered a mandate for action on climate".

91%

Share of Australia's electricity supplied by fossil fuels

"I think it's a resounding statement from the Australian public that they think that climate change needs to be taken much more seriously," says Mark Howden at the Australian National University in Canberra.

Australia has been notoriously slow to transition away from fossil fuels, largely due to vested interests. The country has the third-largest reserves of coal and still relies on fossil fuels to generate 91 per cent of its electricity. It also rakes in about A$100 billion a year from exporting coal.

During its nine years in power, the Liberal-National Coalition has actively tried to delay coal plant closures even when plants are no longer economically viable. Outgoing prime minister Scott Morrison once brought a lump of coal to parliament, announcing: "This is coal. Don't be afraid. Don't be scared. It won't hurt you."

However, three years of extreme droughts, fires and floods have made Australians increasingly fearful of climate change and anxious for change, says Cassandra Star at Flinders University in Adelaide. "If we were ever going to have a climate election, this was it," she says.

Labor has promised to increase Australia's 2030 target for reducing carbon emissions from 26-28 per cent below 2005 levels to 43 per cent. The party says it will roll out more solar and battery infrastructure, update the electricity grid so that it can handle more renewable energy, make electric vehicles cheaper and invest in green hydrogen and steel.

There is a good chance that Labor will be pushed to go further by the Greens, who want a 2030 emissions reduction target of 75 per cent, and the teal independents, who have mostly advocated for 60 per cent, says Star.

Modelling by the University of Melbourne shows the target should be at least 74 per cent for Australia to contribute its "fair share" to keeping global warming within 1.5 °C. ▮

Plant science

Priceless samples from Ukraine's seed bank destroyed in Russian attack

Michael Le Page

TENS of thousands of seed samples that were part of Ukraine's national seed collection have been destroyed by a Russian bomb attack on the city of Kharkiv, according to a video posted on YouTube on 14 May. The collection was the 10th largest in the world and supplied seeds to breeders in many countries, including Russia.

"Almost everything turned into ashes," said Sergey Avramenko at the Plant Production Institute in the video. "There were varieties that were hundreds of years old and cannot be restored."

The video, which is no longer available online, shows that the contents of a large room containing bags and packets of seeds have been almost completely destroyed. Only a handful of seeds weren't burnt black and these probably won't germinate, said Avramenko.

At one point in the video, he showed a puddle of melted metal on the floor. That metal was aluminium, according to Avramenko, meaning temperatures in the room reached at least 660°C. "In these rooms, there was no military or territorial defence, there was only a scientific institution," he said.

Seed banks, also called gene banks, preserve the genetic diversity of plants as a repository for breeders. When the Nazis invaded Ukraine during the second world war, they preserved the seed collection because they recognised its importance, said Avramenko in the video. But Russia deliberately targeted the institute, he claimed.

Before the war, the National Gene Bank of Plants of Ukraine in Kharkiv stored more than 150,000 samples of over 1800 plant species from around the world. However, it appears most of these haven't been destroyed.

"Despite recent media reports, our current understanding from the management of the gene bank is that the main seed collections are still safe and that the damage we are seeing online is mainly to an agricultural research station," Stefan Schmitz, head of the Crop Trust in Bonn, Germany, told *New Scientist*.

"Nevertheless, the main collections of the national gene bank system are at high risk – as are the dedicated staff who maintain them. We are relieved to hear that no lives have been lost among the staff. We are doing what we can to help them," he says.

Seeds can't be stored indefinitely in seed banks. They have to be resown every few years, with fresh seeds collected and stored, which is why maintaining them is expensive. According to Avramenko, the seeds in the room were those sent out to be resown in spring.

"Any loss of the collections will have a negative impact on prospects for global food and nutritional security," says Schmitz (see page 18). Some of the varieties are also found in seed banks elsewhere, but many are at risk of being lost forever, he says.

The Plant Production Institute in Kharkiv didn't respond to a request for comment.

SERGEY AVRAMENKO/YOUTUBE

Seeds burnt in a bomb blast in Kharkiv, Ukraine

Space exploration

ISS docking success for Boeing's Starliner spacecraft

BOEING's Starliner spacecraft docked with the International Space Station (ISS) for the first time on 21 May, despite an issue with its thrusters.

The craft is designed to send astronauts to orbit from US soil – something only SpaceX can do at the moment – and this uncrewed test flight is an important step in achieving that.

Starliner took off at 22.54 GMT on 19 May from Cape Canaveral in Florida on top of a United Launch Alliance Atlas V rocket. While the launch was successful, two onboard thrusters out of 12 failed as Starliner manoeuvred into orbit. Backup thrusters ensured the spacecraft could continue to the ISS. As *New Scientist* went to press, it was due to return to Earth on 25 May.

Starliner has had a troubled past. In 2019, it was unable to reach the ISS after a faulty clock meant the rocket's boosters failed to properly fire after lift-off. In 2021, just hours before another scheduled launch, pre-flight checks revealed corroded valves that required repair, and the launch was postponed until 19 May.

Boeing is now set to join SpaceX as the second commercial outfit capable of flying US astronauts to space, with Starliner's first crewed launch pencilled in for later this year.

Part of the reason for NASA encouraging the commercial spacecraft sector in the US was to avoid relying on Russian spacecraft to reach the ISS, an issue that has become more pressing since the country's invasion of Ukraine.

"To have two different ways of getting into space will mean that, should there be problems on either one, they have another means to get there," says Libby Jackson at the UK Space Agency. "That's really important for ensuring that we have continued and safe operations of the International Space Station."

Alex Wilkins

JOHN RAOUX/AP/SHUTTERSTOCK

Starliner blasted off on a United Launch Alliance Atlas V rocket on 19 May

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Plant science

Tomatoes gene-edited to produce vitamin D

Adam Vaughan

BIOLOGISTS have created gene-edited tomatoes that offer a new plant-based source of vitamin D, as the UK government prepares to change the law to allow such "precision-bred" food to be sold in supermarkets.

Eating two of the tomatoes a day would address typical deficiencies in vitamin D, which about a billion people globally don't get enough of, particularly in sun-starved northern latitudes. The edited fruit also offers a new vegan alternative to standard vitamin D supplements. Most of those containing vitamin D3, one of two main types of the vitamin, are sourced from lanolin in sheep wool.

However, despite the UK government introducing a bill on 25 May to treat gene-edited food differently to genetically modified organisms, the tomatoes face a series of technical and economic hurdles before they can become widely available.

1 billion

Estimated number of people worldwide with low vitamin D

They were made by editing a gene called *Sl7-DR2* to stop the plant producing an enzyme that converts provitamin D3, a precursor to vitamin D, into cholesterol (*Nature Plants*, doi.org/hv7f).

"We altered a very small fragment of a part of this gene," says Jie Li at the John Innes Centre in Norwich, UK, who led the research. "Comparing with the non-edited tomato plants, we didn't see any effect on growth, development or yield in our edited plant. It just looked like a normal tomato fruit."

Stefan Jansson at Umeå University in Sweden says the editing opens up new opportunities. "They have made an important and useful change by changing a few letters in the critical gene," he says. ▮

Energy policy

UK expects to be a net electricity exporter by 2030

Adam Vaughan

THE UK expects to become a net exporter of electricity in just eight years' time as the country implements its Net Zero Strategy.

The milestone would reverse decades of the country being a net power importer, using subsea cables to draw more electricity from French nuclear reactors and other European power stations than it sends in the other direction. Electricity imports into the UK hit a record level in August last year.

To meet its goal of reaching net-zero emissions by 2050, the government plans to encourage a wave of offshore wind farms and solar installations this decade. These are expected to produce such an abundance of inexpensive power that by 2030, Great Britain will be a net exporter, according to scenarios being considered by the Department for Business, Energy & Industrial Strategy (BEIS), which underpin the UK's flagship Net Zero Strategy.

The scenarios don't include Northern Ireland, whose electricity sector is integrated with that of the Republic of Ireland, but the projections would still make the UK a net exporter because energy production and consumption in Northern Ireland are such a small fraction of the UK total.

This month, a glut of gas in the UK has seen power stations burning more of it than usual, resulting in electricity flowing to continental Europe, but this is an unusual and temporary situation, whereas the change from 2030 is expected to be permanent.

"The UK plans to encourage a wave of offshore wind farms and solar installations"

Officials at BEIS anticipate that by 2050, Great Britain will be exporting the equivalent of about a fifth of total electricity generation today via the subsea cables, known as interconnectors. There are seven interconnectors between Great Britain and continental Europe today, and more are planned.

"In the future, we'll likely be exporting because we have spare power," says Jess Ralston at the Energy and Climate Intelligence Unit think tank. "So net exports are likely to occur when it's very windy and/or demand is low. It's a consequence of having a large wind fleet that can meet the bulk of UK demand even when it's not that windy and turbines aren't operating at 100 per cent. So prices would be low, there'd be no risk to security and it'd lower emissions."

Simon Evans at the website Carbon Brief says the projections are notable because BEIS has previously tended to skew towards assuming imported energy will help to meet the UK's carbon goals. However, he says there is considerable uncertainty in the scenarios because there are so many variables, from how many interconnectors get built to levels of carbon pricing in the UK and the European Union.

Nonetheless, a growing number of analyses suggest the direction of travel is clear: that a boom in wind and solar power generation in the UK will lead the country to become a net exporter. One recent study by the consultancy LCP found that growth in renewables would mean the UK would have an excess of electricity about 53 per cent of the time in 2030. Another report last year, by S&P Global Platts, said the UK would be a net power exporter by 2026.

The BEIS scenarios, dated February and published in March, provide a peek behind the curtain at the assumptions for the Net Zero Strategy. The UK government has repeatedly refused freedom of information requests asking for the document with a full breakdown of those assumptions. ▮

CHRIS RATCLIFFE/BLOOMBERG VIA GETTY IMAGES

Offshore wind turbines near Great Yarmouth in Norfolk, UK

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Astronomy

Is this black hole picture wrong?

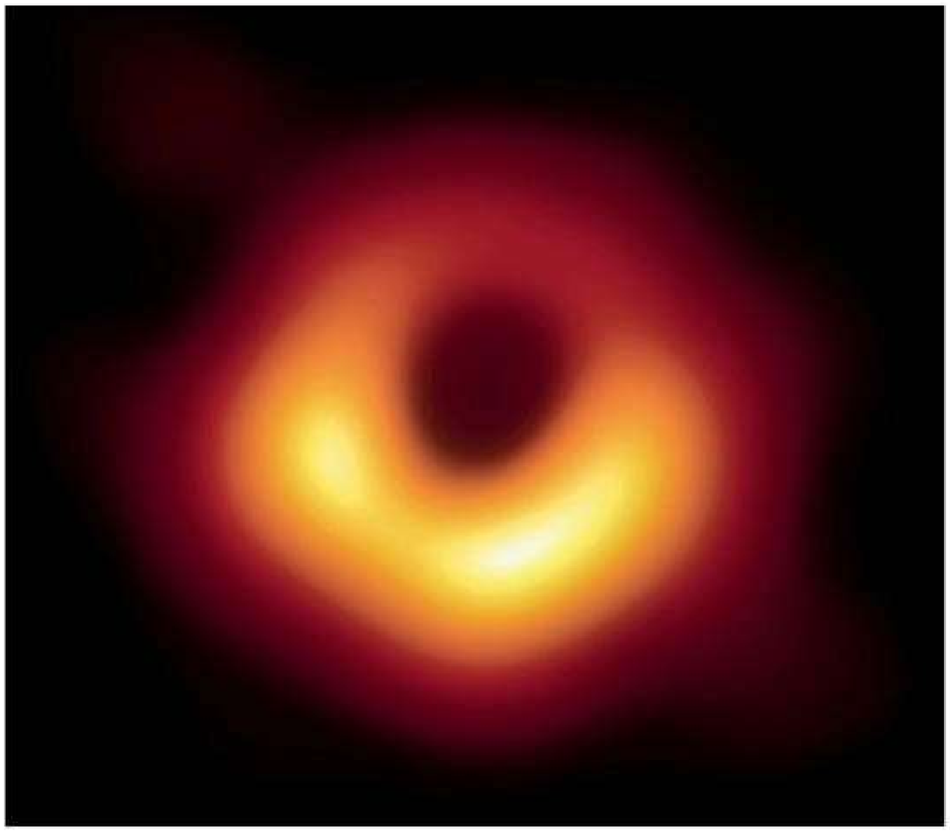
The first ever image of a black hole, at the centre of the galaxy M87, showed a bright outer ring of light in line with predictions, but a new analysis suggests that may not be accurate, reports **Leah Crane**

THERE may be a problem with the first image of a black hole. After three years of analysis, a group of researchers in Japan has produced an image of M87* – the supermassive black hole at the centre of the M87 galaxy – that looks markedly different from the one released by the Event Horizon Telescope (EHT) collaboration in 2019. The researchers claim that the EHT group may have made a mistake.

To make the first black hole image (pictured), the EHT combined the power of eight radio telescopes around the world. The array essentially operates as one giant telescope, called an interferometer. Each pair of telescopes records a particular wavelength of light, and then all the information is combined to create the final image. "If the image on the sky were a musical song, you can think of the interferometer as measuring individual frequencies or notes in that song," says EHT project scientist Geoffrey Bower.

"These are the most thoroughly vetted interferometric images ever published"

These "notes" are combined using an algorithm that incorporates other information about the black hole and the telescope set-up to fill in the blanks and turn the interferometer's measurements into a picture. The most pronounced feature of the final image from the EHT is a bright ring – a result of the black hole's extreme gravity warping the light from the hot plasma swirling around it. But filling in the blanks to generate an image involves making some assumptions. If you start with a different set of assumptions, you will get a different picture.



EHT COLLABORATION

The EHT image of the black hole at the centre of galaxy M87

That is what Makoto Miyoshi at the National Astronomical Observatory of Japan and his colleagues have done, and their results have them questioning whether this ring is really there. They reprocessed the data from the EHT with one significant difference: rather than restricting the light collected by the telescopes to a relatively small area as the EHT collaboration did, they assumed a much larger field of view.

With this change, no ring appeared in their final image. Instead, the image shows two distinct bright spots – one representing the area directly around the black hole, and another off to the side, possibly representing the base of a jet of matter that previous work has shown blasting out of M87* (arxiv.org/abs/2205.04623).

Miyoshi says the restricted field of view could have caused artefacts in the EHT's final image that are related to the arrangement of the telescope network, not real structures in space. "It may be that the same mistake formed the ring image in the case of [the recently released picture of] Sagittarius A*, too," says Miyoshi, referring to the black hole at the heart of the Milky Way. His work suggests that the EHT image of M87*, and perhaps that of Sagittarius A* as well, shouldn't appear to be doughnut-shaped.

Defending the ring

However, Bower says that Miyoshi's approach of relaxing the EHT's constraints on the field of view is incorrect and that the EHT group's original field of view reflects the area that the telescope actually observed, not an arbitrary choice. "[Miyoshi's team] used this extraordinarily large field of view, so they scatter the intensity of the light around this image," he says. "You can get almost anything you want if you give yourself that kind of freedom."

The EHT collaboration had four separate teams using different methods to turn the data into the final image, one of which was the same method that Miyoshi's team used, but with the field of view constrained. "These are the most thoroughly vetted interferometric images that have ever been published," says Bower.

They show no sign of the jet in M87*. This isn't unexpected, though, because the jet is expected to primarily emit light at lower frequencies than the ones that the EHT detects.

The ring structure seen in the final image is also not particularly unexpected, although the researchers hunted extensively for any way in which the picture might differ from theoretical predictions.

"We actually tried very hard not to find a ring," says EHT researcher Ziri Younsi at University College London. "We used traditional algorithms that have been used by the radio astronomy community for decades, and we used newer algorithms, and they all converged on the result we published."

The EHT collaboration put out a statement standing by its analysis, but Miyoshi and his colleagues are standing by their criticisms as well.

The EHT has taken new observations with additional telescopes added to the array, and researchers are now working on turning higher-resolution measurements taken in 2018 and early 2022 into images.

"A future image from those data sets will be a really important test of the overall method," says Bower. If other reanalyses of the original data don't settle this debate, the new data certainly will.

Environment

Climate change means people are losing 44 hours of sleep per year

Adam Vaughan

ECO-ANXIETY is already causing people to lose sleep over climate change. Now, a global study has found that a warming planet is also affecting how long people sleep, and the problem will get worse this century even if humanity manages to rein in its carbon emissions.

Our measurements of the impact of above-average night temperatures on sleep have previously been limited by being confined to single countries, lab studies or notoriously unreliable self-reporting of sleep.

To glean a better real-world picture, Kelton Minor at the University of Copenhagen, Denmark, took data from sleep-tracking wristbands used by 48,000 people in 68 countries between 2015 and 2017.

He and his colleagues then paired the sleep data with local weather data, revealing that unusually hot nights are causing people to fall asleep later, rise earlier and sleep less. Already, the evidence suggests that people are losing an average of 44 hours of sleep each year. By 2100, the researchers estimate people will lose 58 hours of sleep a year if emissions go unchecked. In a lower-emissions future, the figure drops to 50 hours (*One Earth*, doi.org/hvvb).

> **"This is the first planetary-scale evidence that warmer-than-average temperatures erode sleep"**

"This is the first planetary-scale evidence that warmer-than-average temperatures erode human sleep. We show that sleep erosion occurs primarily by delaying when people fall asleep," says Minor.

Some groups are hit worse than others. Above-average heat at night had a larger impact on sleep loss for people in lower-income countries, women and older people. For those aged 65 and older, the effect on sleep of a 1°C increase in the minimum overnight temperature was at least twice that for younger age groups.

It is possible that some of those living in higher-income countries are more likely to install air conditioning to help them cope with the heat, but Minor says the findings in the study don't allow him to make this link definitively. Moreover, air conditioning can drive up emissions due to fossil fuel energy use.

Susan Clayton at the College of Wooster, Ohio, says the study's methodology is sound and includes a "very thorough" examination of other explanations. "The implications are clear: higher temperatures associated with climate change are already reducing the amount of sleep people get and are projected to do so even more. Since we know that lack of sleep can negatively impact mood, behaviour and health, this is concerning," she says.

Ivana Rosenzweig at King's College London says the study showcases the power of big data. But she says the measured effect when considered from the perspective of a single night is small. "Mere minutes of sleep per night," she says.

However, Minor says the type of person who chooses to wear a sleep-tracker may also be more likely to have access to other technologies that can curb the effect of hot nights on their sleep. For that reason, he says the team's estimates of climate change's impact on sleep are likely to be on the low side. ▮

Animal behaviour

A taste of urine helps dolphins spot their friends

A trio of bottlenose dolphins swimming in the Caribbean

TOM CAMPBELL/SPLASHDOWN/SHUTTERSTOCK

BOTTLENOSE dolphins can recognise familiar individuals just by tasting their urine, similar to how the smell of a friend's perfume can be part of our mental idea of them.

Jason Bruck at Stephen F. Austin State University in Texas and his colleagues found that bottlenose dolphins spent about three times longer sampling water that contained urine collected from familiar dolphins than they did if it was from unfamiliar dolphins, suggesting they recognised their friends' unique urine tastes.

This sampling involved "opening their mouths and running their tongues through the water where we poured the urine in front of them", says Bruck.

Bottlenose dolphins are also known to identify each other through signature whistles that they invent early in life. The latest finding indicates they can recognise each other in more than one way – either through taste or sound.

They also investigated areas for longer when they could taste a friend's urine and hear their whistle via a speaker at the same time than they did when whistle of another known individual was played (*Science Advances*, doi.org/gp58r6).

This suggests they have concepts of individual friends in their minds that connect their unique taste and sound, says Bruck. It is similar to how we have mental representations of our friends that integrate multiple elements, such as their perfume's smell and the sound of their voice.

Being able to identify other dolphins through urine is useful because it hangs around, he says. "If the urine cue can persist, then another dolphin would be able to detect that and determine if a past ally or enemy is in the area," says Bruck. Another advantage is being able to detect potential mates, he says. ▮

Alice Klein

Briefing

A breakthrough moment for AI?

UK firm DeepMind has released Gato, an AI that can perform 600 tasks – but it isn't truly intelligent, finds **Matthew Sparkes**

GATO is an extraordinary AI. It can play Atari games, accurately caption images, chat naturally with a human and stack coloured blocks with a robot arm, among about 600 other tasks. But does it bring us closer to the development of machines with the general intelligence seen in humans?

What is the significance of Gato?

Nando de Freitas at DeepMind tweeted that "the game is over" when the firm released Gato, and suggested that simply making AI models bigger and more efficient – and feeding them more training data – would be key to achieving artificial general intelligence (AGI).

What is AGI?

AGI is a term used for a model that can learn any intellectual task that a human being can. Gary Marcus at US software firm Robust.AI says the term is shorthand. "Roughly, we mean systems that can flexibly, resourcefully solve problems that they haven't seen before, and do so in a reliable way."

How will we know if AGI has been achieved?

Various tests have been proposed that would grant an AI the status of AGI, although there is no universally accepted definition. Alan Turing famously suggested that an AI should have to pass as human in a text conversation, while Steve Wozniak, co-founder of Apple, has said he will consider AGI to be real if it can enter a random house and figure out how to make a cup of coffee.

Another proposed tests is sending an AI to university and seeing if it can pass a degree.

Does AGI exist yet?

Yann LeCun, chief AI scientist at Facebook's owner Meta, says there is no such thing because even humans are specialised. In a recent blog post, he said that a "human level AI" may be a useful goal to aim for, where AI can learn jobs as needed like a human would, but that we aren't there yet. "We still don't have a learning paradigm that allows machines to learn how the world works, like human and many non-human babies do," he wrote. "The solution is not just around the corner. We have a number of obstacles to clear."

> **"AGI is a term used for a model that can learn any intellectual task a human being can"**

So is Gato an AGI?

Although de Freitas seems to think Gato is an important step on the road to AGI, others are less sure.

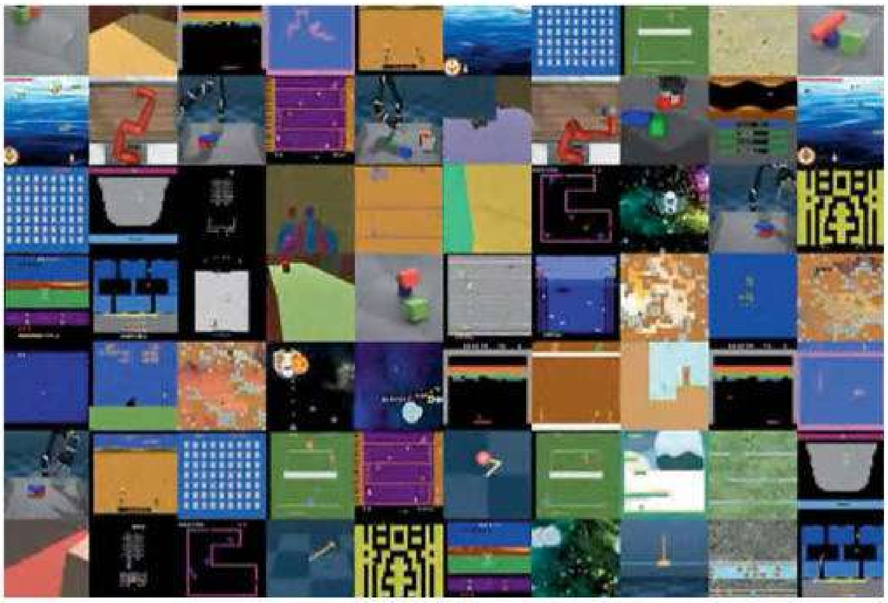
Oliver Lemon at Heriot-Watt University in Edinburgh, UK, says the claim that the "game is over" isn't accurate, and that Gato isn't AGI. "These models do really impressive things," he says. "However, a lot of the really cool examples you see are cherry-picked; they get exactly the right input to lead to impressive output."

In fact, even some of DeepMind's own scientists are sceptical. David Pfau, a staff research scientist at DeepMind, tweeted: "I genuinely don't understand why people seem so excited by the Gato paper. They took a bunch of independently trained agents, and then amortized all of their policies into a single network? That doesn't seem in any way surprising."

So Gato isn't important after all?

It might be. Lemon says Gato, and other AIs like it, are creating surprisingly good results. He thinks that training an AI to accomplish varied tasks may eventually create a solid foundation of general knowledge on which a more adaptable model could be based.

DeepMind was unavailable to comment. ▮



DEEPMIND

Gato can complete a wide range of tasks, including playing computer games

Botany

Plantations grow better if they contain many species of tree

Carissa Wong

JUAN CARLOS MUNOZ/ALAMY

TIMBER-producing tree plantations that contain at least two different tree species grow better than those with just one. The finding suggests that increasing the tree diversity in areas of reforestation can increase the amount of wood produced and carbon stored.

Shaopeng Wang at Peking University in Beijing and his colleagues analysed growth data from 273 previous studies that covered a total of 243 species used in 255 plantations around the world. The team compared how trees fared in monoculture and multispecies plantations that were grown in the same regions, for the same amount of time and with the same planting density.

This revealed that trees grown alongside at least one other species were 5.4 per cent taller, 6.8 per cent wider and had around 25 per cent more above-ground mass compared with those in plots with just one species.

The researchers also found that deciduous trees, which drop their leaves in the autumn, benefitted from being next to evergreen trees, which keep their leaves all year, and vice versa (*Science*, doi.org/hvsn).

"Our results showed that differences in leaf shape and leaf lifespan underpin stronger [co-benefits] within mixtures of tree species," says Wang. The team suggests this is probably because trees can access resources more easily when they have different needs to neighbouring trees. ▮

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Nutrition

Tackling the global food crisis

Geopolitical events and climate change are making food unaffordable across the planet. What can be done, asks **Michael Le Page**

A man carries grain from a World Food Programme facility in Kandahar, Afghanistan

JAVED TANVEER/AFP VIA GETTY IMAGES

HUNDREDS of millions of people around the world are going hungry as food prices continue to rise as a result of everything from the coronavirus pandemic to India's extreme heatwave to the ongoing war in Ukraine. Without meaningful action to make food more affordable, we may see starvation and political upheaval.

"The war in Ukraine, on top of all the other global crises, threatens tens of millions of people with food insecurity, malnutrition, mass hunger & famine. There is enough food in our world for everyone, but we must act together, urgently & with solidarity," tweeted António Guterres, the United Nations secretary-general, on 19 May.

Food prices (see graph, opposite) had already reached an all-time high before Russia's invasion of Ukraine. Globally, nearly 300 million people – another record high – weren't getting enough food, and, of those, 50 million were "knocking on famine's door", said the head of the UN World Food Programme, David Beasley, at a UN Security Council meeting on 19 May.

Unbalanced diet

Now things are set to get even worse. The hardest-hit nations include the Democratic Republic of the Congo, Afghanistan, Ethiopia and Yemen, but even in wealthier countries, people on low incomes are being affected by rising prices, with food banks in the US and UK reporting soaring demand.

Not all who can afford enough calories to live can stretch to a balanced diet, says Matin Qaim at the University of Bonn in Germany. That means people don't get enough key micronutrients, such as iron, which can lead to health issues, such as a lack of red blood cells.

Farmers cross a river by tractor near Zaporizhzhia, Ukraine, because a nearby bridge has been destroyed

SMOLIYENKO/UKRINFORM/FUTURE PUBLISHING/GETTY IMAGES

In children, such deficiencies can have detrimental effects that last a lifetime, says Qaim. In 2020, a fifth of under 5s – 150 million of them – were estimated to be affected by such "stunting". This situation may have become worse even before the latest price spike: a study published last week found that the cost of nutritious food rose more in countries with higher numbers of covid-19 cases.

The food crisis isn't just a humanitarian issue. Soaring food prices could lead to widespread unrest, mass migration, political instability and yet more wars. When prices spiked in 2007 and 2008, there were riots in many countries across the world. Another price spike in the 2010s is widely thought to have played a major part in the so-called Arab Spring, which, among other things, led to the continuing war in Syria.

"If you are not careful, we are going to have significant issues in other places [besides Ukraine] around the world," Beasley warned global leaders at the Munich Security Conference on 13 May. "Otherwise, you have a perfect storm, or a crisis within a crisis. And that we can't afford right now."

After the early 2010s, food prices fell somewhat. They began climbing sharply in 2020, for several reasons. The major one was the coronavirus pandemic disrupting supply chains around the world. The food that was grown didn't always reach the places it was needed because of bottlenecks with shipping and higher transport costs.

"There is enough food in our world for everyone, but we must act together, urgently and with solidarity"

There were also extreme

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weather events around the world, from drought in Brazil to severe heat in Canada, that hit crop yields. Such events are becoming more common and extreme because of global heating.

What's more, after dropping at the start of the pandemic, fossil fuel prices have been rising, and there is a strong link between food and energy prices. Farming is an energy-intensive industry, using fossil fuels to do everything from making nitrogen fertiliser to transporting the resulting food. While estimates differ, one 2019 study found that 64 per cent of the variance in food prices could be explained by the oil price.

Double whammy

This makes Russia's invasion of Ukraine a double whammy. It is leading to direct shortages, because Ukraine produces, among other things, 9 per cent of global wheat exports and 40 per cent of sunflower oil exports. The invasion is also causing global energy prices to rise further, which will push up food prices indirectly.

High food prices aren't always a bad thing, says Derek Headey at the International Food Policy Research Institute (IFPRI). If prices stay high for several years, it can alleviate rural poverty because farmers earn more, hire more workers and invest in technology.

But the current spike in prices is happening at a time when the livelihoods of many people have already been hit by the pandemic, says Headey. "It's happened so suddenly now, and happened at a bad, bad time."

Many countries have run up big debts, so governments have less scope for helping those who are struggling. "It's a crisis coming on top of a crisis, so it's a huge challenge for social protection," says Headey. "I see this persisting for quite a while."

Events in Ukraine will continue to have a big impact on food prices over this year. The country still has significant stocks of wheat and sunflower oil, but its Black Sea ports are blockaded by Russia, and the infrastructure isn't there to export much via land routes despite efforts to increase this. There is a danger that the next harvest could be lost as a result.

"If we do not sell what we now have in our stocks, we will have no place to store the new harvest," the Ukrainian foreign minister, Dmytro Kuleba, said at a G7 meeting in Germany on 13 May. "If that happens, then the entire agricultural cycle in Ukraine will be disrupted."

Then there is the weather. It is only May, but already China has warned that its winter wheat crop could be the "worst in history" due to heavy rains, the US winter crop has been affected by drought, there have been floods in Australia and South Africa, and extreme heat in India, Pakistan and most recently Spain.

There is no doubt that global heating is making such extreme weather events more common. According to the UK Met Office, for instance, climate change has made record-breaking heatwaves in north-west India and Pakistan more than 100 times more likely.

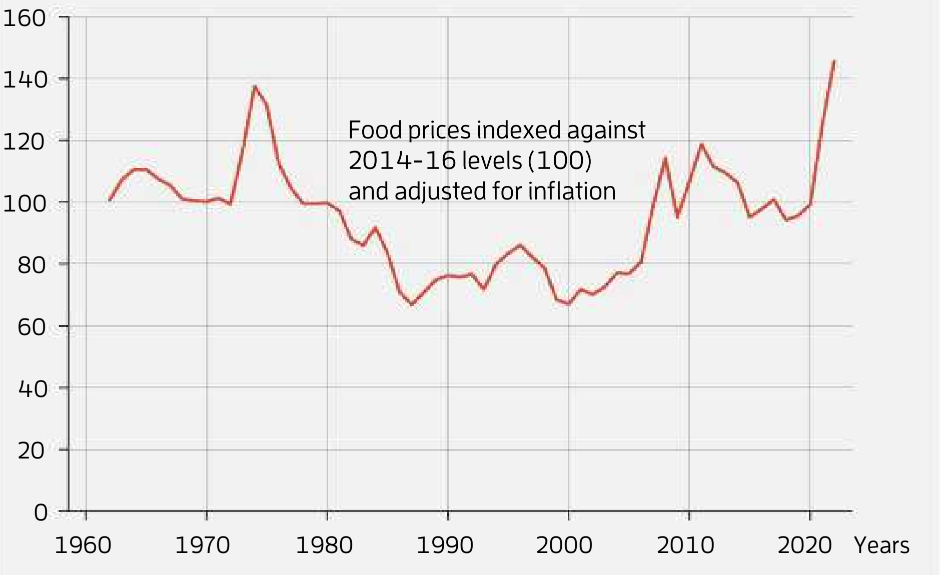
Even if no more extreme weather events hit yields this year, there is another crucial factor at play: high fertiliser prices. Fertiliser prices started rising in 2020 along with fossil fuel prices, and have gone up even further because Russia and Belarus are major exporters. They now cost three or four times as much as they did before the pandemic.

> **"The interconnectedness between the food sector and the energy sector is pretty worrying"**

This could have major knock-on effects (see "The fertiliser problem", page 20). How much a lack of fertiliser matters was demonstrated by an ill-advised 2021 ban on fertilisers in Sri Lanka: within six months, rice yields were down by 20 per cent and local prices up by 50 per cent.

Lean times

Food prices have hit a record high and continue to rise



SOURCE: FAO FOOD PRICE INDEX

"In many regions, farmers cannot afford to bring fertilisers to their farms or, even if they could, the fertilisers are not available. Many fields are not being planted," said Theo de Jager, the president of the World Farmers' Organisation, during a virtual meeting hosted by IFPRI on 4 May.

Other farmers are changing what they plant. In the US, for instance, Qaim says farmers are planting less wheat and more soya beans because soya plants needs less fertiliser. That could ease vegetable oil prices, he says, but lead to even higher wheat prices.

Despite all these issues, the latest outlook for 2022 from the UN Food and Agriculture Organization (FAO), issued on 6 May, remains positive. It has scaled back its forecast for wheat, but still predicts that both wheat and overall cereal production will be slightly higher than last year.

With so many factors in play, it is impossible to predict what will happen to food prices next, says Stefan Schmitz at the Crop Trust non-profit organisation. But they could certainly rise higher. "We have to prepare for a worse and worse situation," he says.

So what should global leaders be doing right now? As *New Scientist* reported in March, turning less food into biofuel would have the biggest immediate impact.

"You can't magic food out of nowhere, but you can reduce biofuel consumption overnight by adjusting policy incentives," says Chris Malins at eco-consultancy Cerulogy. "Reducing biofuel consumption could compensate for the war in Ukraine many times over."

This has recently been acknowledged by some political leaders. "Agricultural land is limited worldwide, and we urgently need it for food, as the war in Ukraine dramatically demonstrates," German environment minister Steffi Lemke told the *Augsburger Allgemeine* newspaper on 29 April.

Even the Malaysian Palm Oil Board, an organisation that usually promotes turning palm oil into biofuel, told Reuters on 25 April that "this is the time to temporarily reconsider food versus fuel priorities". But many in the biofuel industry are lobbying against any changes, and as yet little has changed, says Qaim.

The fertiliser problem

Prices of fertilisers have shot up, adding to the food crisis – without chemical fertilisers, global food yields could halve. Is there anything that can be done?

Plants need three main kinds of fertiliser: nitrogen, phosphorus and potassium. Nitrogen fertiliser is made by combining nitrogen from the air with hydrogen. Because the hydrogen currently comes from natural gas, the cost goes up when gas prices rise. This also means fertiliser manufacturing is a significant source of greenhouse gases.

A number of companies around the world plan to make nitrogen fertiliser using renewable energy instead, which could reduce emissions and help prevent price spikes. But it could be many years before this is done on a large scale.

Another solution is to get plants to make their own nitrogen. Legumes – beans, soya, lentils and the like – can already do this and biologists are trying to engineer this capacity into other crops.

Phosphate and potassium fertilisers, by contrast, are minerals usually obtained by mining and so are a limited resource. According to one study, we could run out of phosphate as early as 2040, although others think we have centuries to go.

In the short term, the issue is that Russia and Belarus are major exporters of all three kinds of kinds of fertilisers, so the war in Ukraine is limiting exports and pushing up prices.

Phosphate fertiliser stored at a warehouse in Cherepovets, Russia

ANDREY RUDAKOV/BLOOMBERG VIA GETTY IMAGES

The vegetarian solution

Another way to free up more food for people is to feed less to farm animals, he says. This could be done by reducing meat and dairy production and encouraging vegetarian diets. Even if the political will to do this existed, however, it would be hard to achieve. In contrast to biofuels, meat consumption isn't driven by easily changed subsidies. Big price rises should curb demand, but according to the FAO Food Price Index, meat prices have only risen slightly so far.

Another thing that countries can do quickly, says Headey, is to sell some of their grain reserves. "The stock situation is much better than it was in 2007 and 2008," he says.

Last but not least, those going hungry need more direct assistance, says Schmitz. "Food aid programmes must be strengthened."

What governments shouldn't do, Qaim, Schmitz and Headey all stress, is impose trade measures such as export bans in an effort to secure domestic food supplies. "Once one country starts to do it, the others will too," says Schmitz. "That's absolutely poisonous."

Unfortunately, this is already happening. In April, Indonesia banned palm oil exports and in May, India banned wheat exports.

300m

Number of people without enough food, globally

150m

Children under 5 who lacked proper nutrients in 2020

9%

Ukraine's share of global wheat exports

However events play out this time, global leaders should seize the opportunity to make future food crises less likely, says Qaim. With a swelling population on a planet increasingly affected by environmental destruction and climate change, food crises could become more frequent and severe if nothing is done.

The bottom line is that we need to produce more food using less land without relying on fossil fuels. "The interconnectedness between the food sector and the energy sector, all the way to geopolitics and things, is pretty worrying," says Headey. Decarbonising farming would lower emissions and decouple food and fossil fuel prices.

We also need more crop diversity to make food production more resilient, says Schmitz. "The current agricultural system puts all its eggs in one basket," he says.

That means preserving and exploiting genetic diversity as well as relying less on just a handful of species for most of our calories. It also means exploiting different types of crops, such as perennials and trees such as breadfruit.

Embracing technologies such as gene editing would help too, says Qaim. "We cannot just bet on organic farming, because that has much lower yields." If more food was produced organically, it would lead to more land clearance, deforestation and biodiversity loss. "That's something we need to avoid by all means," he says.

Qaim hopes the crisis will spur countries to shrink biofuel and meat production, and so reduce greenhouse emissions, boost biodiversity and ease the food crisis. "In my eyes, these are things that would lead to win-win-win outcomes," he says. "Wouldn't it be a great opportunity to use the crisis to get things started?" ▮

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Chemistry

Recycle old wood into a material stronger than steel

A PRODUCT made from recycled wood is five times stronger than natural wood and can be made from any timber waste, including shavings and sawdust.

Wood is a hugely versatile material, but millions of tonnes go into landfill each year. A truly circular economy will need it to be re-used on a grander scale.

Orlando Rojas at the University of British Columbia, Canada, and his team have invented a way to remove lignin, a glue-like component inside plant cell walls, and expose cellulose nanofibrils – tiny fibres also found in the plant cell wall.

When two pieces of wood treated in this way are brought together, the nanofibrils bind to create what the researchers call "healed" wood. Although this no longer looks like natural wood, it has better mechanical properties. Tests show it resists breaking better than stainless steel or titanium alloys (*Nature Sustainability*, doi.org/hvtm).

"We get a mechanical strength that supersedes the strength of the original material," says Rojas. "It works because we use the inherent properties of cellulose, which is a material that binds together very strongly by something called hydrogen bonding."

Not only can wood treated this way be re-used to create new objects, but the treatment process can be performed repeatedly on the same pieces of wood to extend their working lifetimes. Rojas and his team didn't examine how much their method would cost if scaled up to an industrial level, but all of the techniques used are well-established. **Alex Wilkins**

Marine biology

Lives of reef fish cut short by boat noise

SOME young fish that live in reefs exposed to boat noise have stunted growth and may be half as likely to survive as fish on quieter reefs.

Spiny chromis (*Acanthochromis polyacanthus*) are fish that fan water over their eggs, boosting oxygen flow that helps the embryos grow. But in reefs with motorboat noise, the parents fan eggs less than in quieter areas.

Sophie Nedelec at the University of Exeter in the UK and her team observed wild spiny chromis nests throughout the breeding season from October 2017 to January 2018 on the Great Barrier Reef. They tagged 59 nests and counted surviving offspring regularly.

Three of the sites were "limited boating" zones, with motorboat drivers asked to keep well away from reefs. The three other sites were "busy-boating" zones, in which the team drove motorboats, usually at full throttle, close to the reef's edge. The team made daily passes totalling about 75 to 90 minutes, to mimic a harbour or popular tourist or fishing areas.

They found that breeding pairs in the limited boating sites were twice as likely to still have living offspring by the end of the three-month breeding season.

The team then captured spiny chromis adults to study them in a lab. The researchers played natural reef sound recordings for 12 hours a day for 13 fish pairs; for another nine pairs, the recordings included 100 minutes of boating noise.

Adults frequently stopped fanning eggs when they heard motorboat recordings. Embryos in the limited boating conditions were 1 per cent longer than those in busy conditions, and 21-day-old hatchlings were 4 per cent longer. The chances of the young fish surviving to 3 weeks old almost doubled without boat noise (*Nature Communications*, doi.org/hvt8). **Christa Lesté-Lasserre**

Coronavirus

Post-infection jab cuts long covid risk

GETTING vaccinated against covid-19 after being infected may lower your risk of long covid.

Daniel Ayoubkhani at the UK's Office for National Statistics (ONS) and his colleagues looked at more than 28,000 people living in the UK, aged 18 to 69. All of them tested positive for the SARS-CoV-2 virus and got at least one dose of a covid-19 vaccine. However, some became infected before the jabs began to be rolled out late in 2020.

ANDY BUCHANAN/AFP VIA GETTY IMAGES

The participants were followed up each month between February and September 2021, and by the end of this period they had all been infected and vaccinated.

About 24 per cent of them said they had long covid to some extent over the seven-month follow-up stage. The researchers then looked at just those who had long covid and had been infected before having a vaccine. This allowed them to see the impact on long covid of a post-infection jab.

Results suggest that getting a single vaccine dose after catching the SARS-CoV-2 virus reduces the risk of continuing long covid symptoms by 13 per cent. The risk fell by a further 9 per cent if the participants got a second vaccine dose by the end of the follow-up period (*The BMJ*, doi.org/hvtz).

The researchers speculate that post-infection jabs may cut long covid risk by attacking residual SARS-CoV-2 viral presence in the body. **Jason Arunn Murugesu**

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Really brief

DAVID HAVEL/ALAMY

Jackdaws 'vote' on mass exodus

Just before huge numbers of jackdaws take to the skies, the birds produce a crescendo of squawks. Researchers argue this may represent each bird casting its "vote" to fly: when the crescendo is absent, the birds don't take flight all at once (*Current Biology*, DOI: 10.1016/j.cub.2022.04.032).

Pollution linked to 9 million deaths

Pollution, including air and lead pollution, was a factor in 9 million deaths in 2019, or 1 in 6 deaths recorded that year. About 90 per cent of the deaths were in low and middle income countries, perhaps tied to rapid industrialisation (*The Lancet Planetary Health*, doi.org/hvsj).

Nanoscopic Möbius strip made in lab

A Möbius strip is a one-sided surface made from a band with a twist in it, and chemists have built a nanoscopic version using the building blocks of a carbon nanotube. Such precise control over tiny molecules could lend itself to other nanoengineering challenges (*Nature Synthesis*, doi.org/hvsm).

Zoology

Young wasps turn cannibal in the nest

SOME wasp larvae take sibling rivalry to a new level by routinely cannibalising their nestmates.

Most wasp and bee larvae grow in individual brood cells within a hive. But solitary wasps like *Isodontia harmandi* are different. Females tuck fertilised eggs and food for their young into tunnel-like chambers such as bamboo cane – so that up to a dozen larvae may share a single cell. Bunking in such tight quarters creates fierce competition for food, and it seems that the larvae frequently turn on each other in order to guarantee a meal.

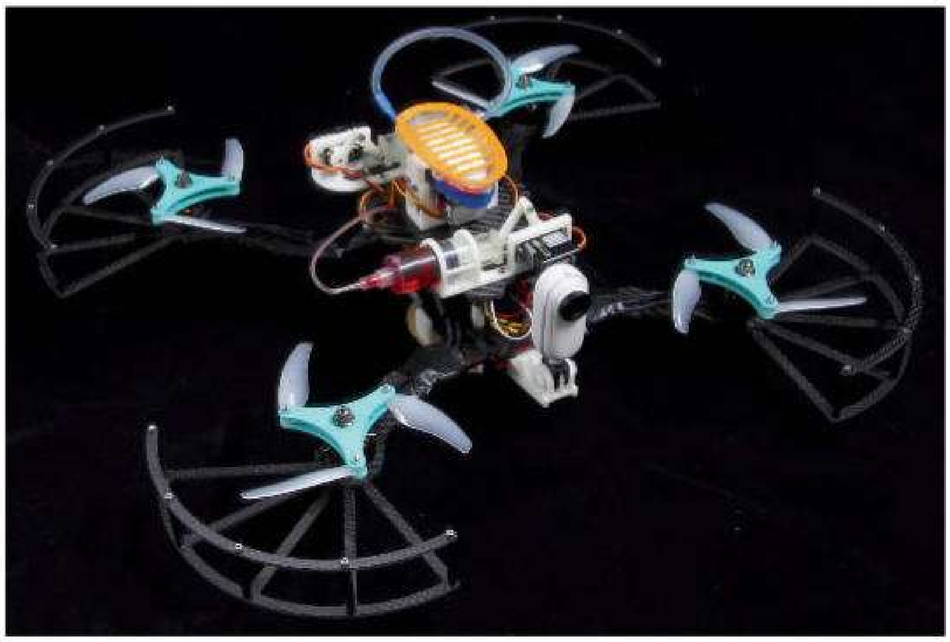
To see if and how these wasps were feasting on their family, Tomoji Endo at Kobe College in Japan and his colleague Yui Imasaki placed bamboo cane in various locations throughout central Japan between 2010 and 2015. They waited for the females to lay their eggs inside, then brought the nests into their lab and watched the larvae develop.

In 30 of the 39 broods observed, young wasps opted to eat each other. The cannibalism continued in 23 of the nests after the cocoon phase began.

Endo and Imasaki found that cannibalism was more likely in brood cells with lots of larvae, and less likely when foods provided by their mother like nectars, plants and smaller insects were abundant (*PLoS One*, doi.org/hvvg).

They think that female wasps produce more offspring to ensure a side buffet is always available to their larvae. That way, some of their young can avoid starvation should traditional food supplies run low. **Corryn Wetzel**

Technology



LEI LI, YIYUAN ZHANG, AND NIANRU MO

Amphibious drone can fly, swim and cling to things

A ROBOT drone that can travel in air and water, and also stick to larger objects, could be useful for tagging wild animals.

It has a suction cup inspired by the remora fish, which attaches itself to larger marine creatures in a symbiotic relationship.

Li Wen at Beihang University in Beijing and his colleagues created a 3D-printed replica of a remora fish suction pad. The result is a small rubber-like pad with a segmented layout that can create a seal even when part of it isn't in contact with a surface. By changing the volume of each segment once a seal has been made – hydraulically in the robot and by muscular changes in the fish – strong suction can be created (*Science Robotics*, doi.org/gp6f9z).

Wen says he was also inspired by the way that kingfishers can fly into water and catch prey, folding their wings as they hit the surface. The drone's rotors have hinged blades that automatically fold and unfold as they change between the high speeds needed for air flight and the lower speeds that work best when in the water.

Wen suggests that the drone (pictured) could be useful in wildlife surveys, for example, flying to spot whales, then diving into the water to attach a tag. **Matthew Sparkes**

Animal behaviour

Fruity smell in urine stresses male mice

FEMALE mice that are heavily pregnant or have recently given birth produce a banana-smelling chemical in their urine that stresses out males, possibly to stop them from killing pups.

Jeffrey Mogil at McGill University in Montreal and his team discovered this by accident. "We were doing experiments with pregnant female mice and noticed that males being used for other experiments in the same room were acting a bit crazy," he says.

To explore further, they gauged stress levels of male mice when placed in a cage near that of another male mouse or a female that was either not pregnant, newly pregnant, heavily pregnant, had recently given birth and was lactating or had given birth in the past and was no longer lactating.

The male mice showed reduced pain sensitivity and elevated corticosteroid levels – both signs of stress – only when caged near female mice that were heavily pregnant or lactating.

The team found that this was because these females produced amyl acetate, which smells of bananas, in their urine (*Science Advances*, doi.org/hv6r). This may warn males of possible aggression by these females. **Alice Klein**

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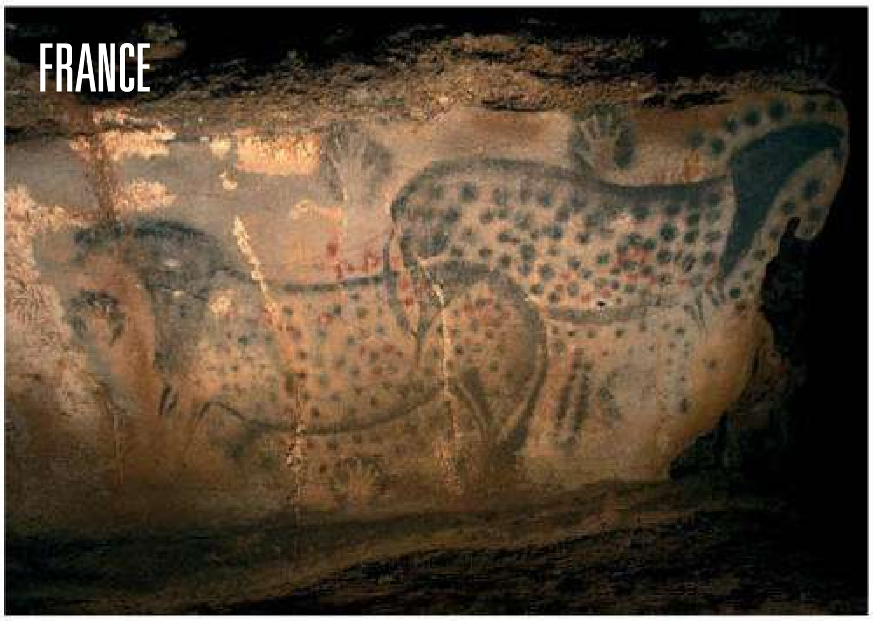

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Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **The Humane Slaughter Association**

Humane Slaughter Association

MFARISH/SRUC

Help us give food animals a better life until the end

Growing numbers of us are concerned about the welfare of animals that provide us with food. Whilst many people recognise the importance of a good life whilst on the farm, animals may also face welfare challenges 'beyond the farm gate'. At the HSA, we play a vital role in improving the welfare of animals in markets, during transport and at slaughter, by providing funding and support for essential research.

PROTECTING THE WELFARE OF AQUATIC ANIMALS

At present, crustaceans (such as crabs and lobsters) are often killed by boiling or carving without first rendering them unconscious, or 'stunning' them. Some electrical stunning devices are available, but they have not yet been thoroughly validated. For other animals such as octopus and squid (cephalopods), the situation is even more dire with no routine stunning methods available. The UK recently recognised that these species are sentient - capable of both negative and positive experiences. Therefore, it is vital that we protect their welfare and minimise suffering. To achieve this, the Humane Slaughter Association (HSA) has provided over £1 million in funding to support two research projects which aim to identify and scientifically validate humane stunning methods for these species.

THE PIG ISSUE

In collaboration with Defra (The UK Government agriculture department), we recently funded a project to look for a humane alternative to stunning pigs in commercial abattoirs. High concentrations of carbon dioxide are commonly used for stunning pigs at slaughter, but there has been concern that this can cause pain and distress. An alternative method – Low Atmospheric Pressure Stunning (LAPS) - was proposed to be more humane, but the research found that LAPS is unlikely to be a humane alternative to carbon dioxide. Whilst disappointing, this provides crucial evidence to protect the welfare of pigs at slaughter and to shift the focus of future research to find other potential improvements.

PRACTICAL AND INTERNATIONAL

We are dedicated to bringing practical and lasting improvements to the welfare of food animals around the world. The HSA works with the livestock industry and animal welfare scientists globally to deliver training and advice on the welfare of animals during transport and at slaughter. We are currently working with colleagues in China, the largest consumer of meat in the world, to deliver training and advice to undergraduate students and those currently working with food animals, helping to improve the welfare of millions more animals.

Want to help?

The HSA is funded solely by donations and legacies from members and supporters. Please help us to continue to make practical and lasting improvements to animal welfare beyond the farm gate at:

hsa.org.uk/support/memberships
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We have reached peak bee, now wasps need time in the sun p34

Culture columnist
Jacob Aron rolls the dice in an immersive cyberpunk game p36

Comment

It's a dog's life

Research now supports what Darwin asserted 150 years ago – dogs feel things like we do. Legislation needs to catch up, says **Jules Howard**

THIS year marks the 150th anniversary of Charles Darwin's *The Expression of the Emotions in Man and Animals*, the third of his major works on evolutionary theory. One of his chief assertions was that dogs, like many other animals, express emotions, including fear and anger, in a way recognisable to humans. That, bluntly, they feel things like we do.

You would be forgiven for thinking that Darwin's argument would have enhanced the welfare of dogs, but change has been slow. In society at the time, the fate of street dogs improved only marginally, and in science, dogs continued to be used in experiments, from Ivan Pavlov's dogs – each fistulated to expose the actions of digestive glands after hearing the dinner-time buzzer – to research dogs apparently "dying in agony" during the production of the rabies vaccine and other life-saving medical interventions.

Today, many people find it abhorrent that dogs could have been treated in such a way. Yet 150 years after Darwin's book, there is still more to do. Science is making great strides in unravelling the emotional complexity of animals, but improvement to animal welfare legislation continues to move forward with tottering baby steps.

It was only last month that the UK government saw fit to pass the Animal Welfare (Sentience) Act, which says some animals should be considered sentient beings, after the European Union legislation on the subject was quietly dropped in the UK post-Brexit. Yet we await details of the committee that will be responsible for correctly applying the act, specifically how it will maintain independence from government and whether it will operate in a transparent manner.

MICHELLE D'URBANO

There are other important welfare issues that need to be addressed, including around illegal puppy smuggling and the 621 per cent rise in ear-cropping, a painful cosmetic procedure that is illegal in the UK. To its credit, the UK government has pledged to tackle these issues, but we await clarity on how this will be done. Meanwhile, the confiscation at UK borders of puppies bred below welfare standards continues to rise, by 260 per cent since 2019. And the use of dogs in UK experimental procedures continues – up 3 per cent in 2020, to more than 4000 procedures.

This is a shame, because if modern science has shown us one thing, it is that dogs deserve better – something Darwin understood 150 years ago and animal cognition studies have since supported.

Research has shown: how the emotional centres of dog brains, observable through fMRI scans, fire up like human ones; that the concentrations of hormones and neurotransmitters associated with emotional responses rise and fall predictably, just as they do in our own brains; that the sociability of dogs – specifically, their interest in us – is found in their genes; and that, in the words of psychology, dogs are capable of strong attachments with us that mirror those seen between human caregivers and children.

Governments should be looking at this swathe of scientific evidence and doubling their efforts to limit the suffering of dogs, whether that is through even stronger import laws to cut off the supply of puppy-farmed dogs, or curbs on the inbreeding of flat-faced dogs, which go on to develop heart defects, skin diseases, obstructed breathing and spinal deformities.

Small statements from the UK government are worth something, but Darwin's literary denouement on animal emotion demands a grander response. Fewer baby steps; more confident strides.

150 years is a long time in science. In dog years, the wait must feel endless. Yet still, we sit. We stay. We listen... we wait. ▮

Jules Howard is a zoological correspondent and author of *Wonderdog*. He will be speaking at New Scientist Live in October

This changes everything

The US myth of free speech

Elon Musk claims he wants to buy Twitter to save free speech, but it is a fallacy that we should be able to say whatever we want, argues **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is **techsploitation.com**

Annalee's week

What I'm reading
Octavia's Brood, *edited by adrienne maree brown and Walidah Imarisha, a fantastic collection of sci-fi stories about politics and freedom.*

What I'm watching
Endless memes of the 14th Doctor, Ncuti Gatwa.

What I'm working on
An article about how engineers are preparing cities for sea level rise.

This column appears monthly. Up next week: Beronda L. Montgomery

LAST month, Elon Musk, the richest person in the world, was about to buy Twitter. He lined up financing for the bonkers $44 billion price tag. Then, he backed off. At the time of writing, he has whiplashed to saying the deal is "not out of the question" if the price comes down.

The whole sequence of events was corporate melodrama at its finest, but it was also an object lesson in how a myth unique to the US about free speech has shaped Silicon Valley media companies.

Twitter is an unlikely darling among techno barons who value exponential growth. In 16 years of existence, Twitter has rarely been profitable. Tech journalist Casey Newton recently called the company "weak", "mismanaged" by former CEO Jack Dorsey, with an "extremely mediocre ads business".

But Musk didn't frame his decision in terms of the company's financial track record or future profits – he claimed he was doing it to save democracy.

In an announcement about the acquisition, Musk said: "Free speech is the bedrock of a functioning democracy, and Twitter is the digital town square where matters vital to the future of humanity are debated."

Roughly two weeks later, Musk declared that he would reverse the Twitter ban on former US president Donald Trump. The ban was put into place in January 2021, after Trump incited an armed insurrection at the US capitol in an attempt to overturn the results of the presidential election.

Musk said it was a "mistake" to ban Trump because it struck a blow against free speech. As if to demonstrate what he imagines free speech should look like on Twitter, Musk recently responded to comments from Twitter CEO Parag Agrawal with a poop emoji. He has also joked that he is buying Coca-Cola "to put the cocaine back in", and then posted a cartoon about how "woke 'progressives'" have driven him to conservatism.

What exactly is Musk saying about free speech here? The First Amendment to the US Constitution defines free speech as protection from government interference in free expression. Put simply, it means the government can't censor the speech of US citizens (unless they are saying something illegal), nor can it compel them to say things they don't want to say (unless they are in court).

> "Ironically, this mythical form of 'free speech' actually functions as a new form of social control"

Because Twitter is a corporation, however, free speech laws don't apply. It can ban anyone it likes. This is perfectly legal.

When Musk and other Silicon Valley media entrepreneurs talk about free speech, then, they aren't talking about the reality of US laws. They are talking about a myth – the myth that everyone in the US is a rugged individual, dependent on no one, and we should be allowed to say whatever we want to whomever we want.

Politicians should be allowed to say that fair elections were "rigged". Racists should be allowed to blame Jewish people for chemtrails. If people in the US say something bad or hurtful, the myth goes, the solution is more speech, not moderation in what we say.

Ironically, this mythical form of "free speech" actually functions as a new form of social control. As media researcher and journalist Peter Pomerantsev points out in his book *This Is Not Propaganda*, the cold war generation fought for unfettered expression as a solution to censorship. More information was supposed to mean more freedom.

But then, in the 21st century, a new crop of anti-democratic politicians figured out that more information can actually work as a form of "mass persuasion run amok" on social media. Speech begets more speech, until the whole internet is an infinite doomscroll.

Instead of being set free, our minds are being contained by a flood of meaninglessly cruel poop emojis.

Ordinary citizens trying to understand the world on social media are overwhelmed with negative messages. We witness vicious, polarised debates and we watch helplessly as mobs of trolls descend on anyone who is deemed unsavoury.

When free speech metastasises into chaos speech, we no longer know what is true or false. We don't trust each other. And productive debates in the public sphere become impossible.

It turns out that information overload is just as toxic to democracy as censorship is. We need to chuck out the US myth that bad speech can be "cured" with more speech. Without moderation, ground rules for debate and thoughtful regulation in our digital public squares, it is impossible for us to reach agreement on anything.

There is a vast and pleasant country between total censorship and total information chaos, and that is where I hope to live one day. I'll save you a seat. ▮

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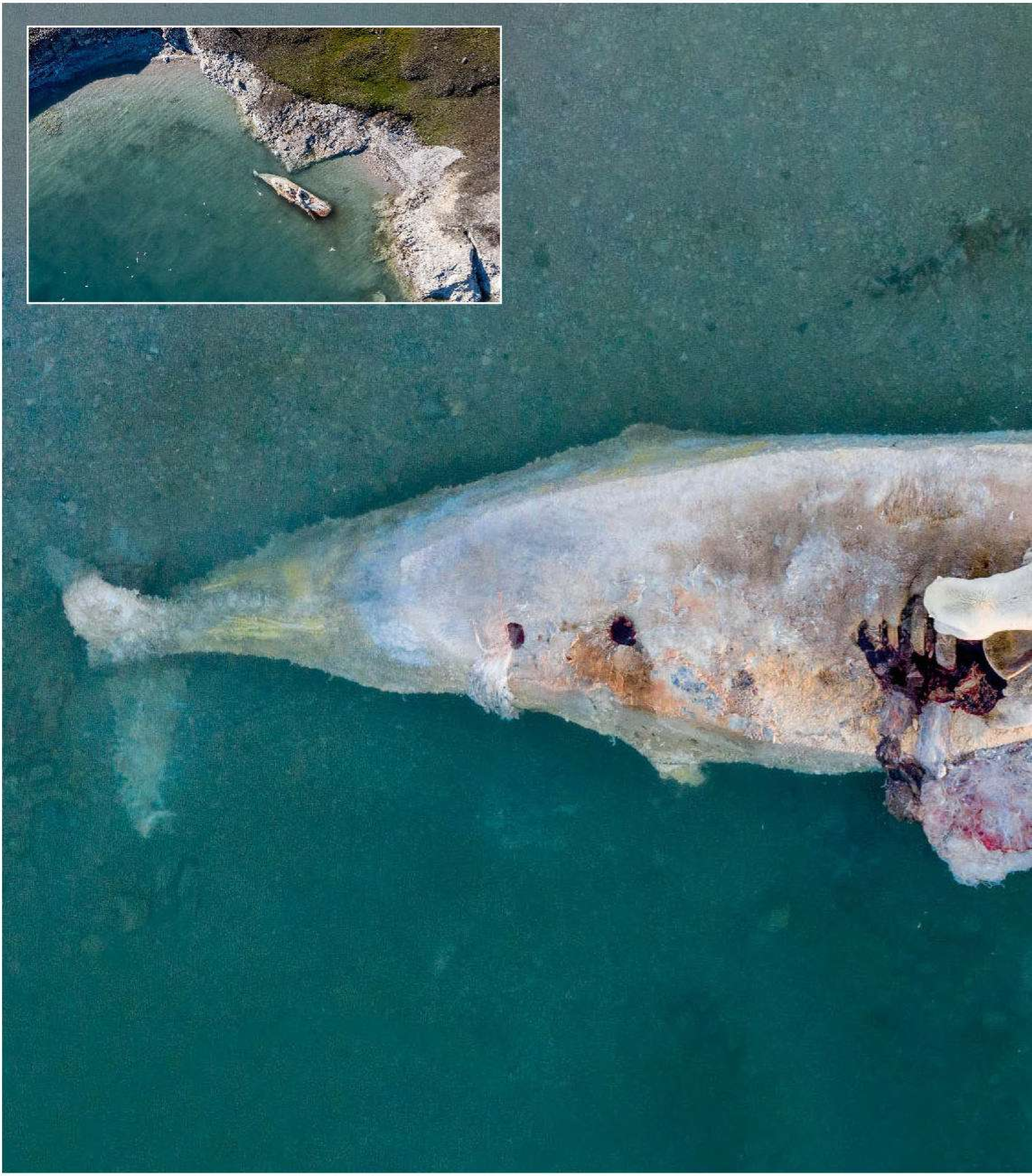

RYAN ATKINSON/DISNEYNATURE

Blubber buffet

Images **Disneynature**

POLAR bears roaming the Arctic wilderness are finding it harder to get an easy meal. As sea ice declines due to climate change, it forces bears onto land, away from their main diet of seals. So, when a dead sperm whale washes up on a beach in Svalbard, a Norwegian archipelago, it is a bit of a gift.

"Luck in Svalbard comes in the form of manna from heaven," says wildlife film-maker Jeff Wilson, who was in the region directing the Disneynature film *Polar Bear*, which includes footage of bears feeding on the whale carcass.

When food is plentiful, competition between the bears is reduced. "That's when you get really interesting interactions," says Wilson. "It was just a whole bunch of bears happy in their own skin, playing with one another."

Wilson thinks the carcass was feeding bears for a second consecutive year, re-emerging after a winter under the ice. "We believe there's about 3 billion calories in a sperm whale," he says.

This free meal may be a relief for the bears, but a 2020 paper suggests that Arctic polar bear populations could be jeopardised by 2100. "[Their] future is very bleak," says Wilson. "Solutions depend on humanity shifting its lifestyle and energy consumption if polar bears are to have any chance at all." ▮

David Stock

JEFF WILSON/DISNEYNATURE

Editor's pick

Reasons to be optimistic that a better world awaits

Letters, 16 April

From Klára Ertl, Barcelona, Spain

Denis Watkins wrote that the loss of hope for a stable future amid crises such as climate change only leads to a pessimistic mindset, and that there is no leadership towards a solution. I couldn't disagree more.

I am 27 and many of my generation have realised too late that their parents' old values around investing in one's future have lost all validity. I was fortunate to realise this early enough that I could get over it and adapt my life goals.

We should abandon our materialism and our trust in institutions, and instead recentre on activism, solidarity, resilience and interdependence. You can survive and do meaningful things without having years of university teaching, and you can raise a child without owning a house or car.

These mirages were never sustainable anyway, only valid for a limited time and place after the second world war, and are costing us the destruction of nature. The safest investments are in human connection, aka social capital. Every year, there are more initiatives, movements and thinkers leading the way.

Intelligence may defy categorisation

14 May, p 42

From Tim Stevenson, Great Missenden, Buckinghamshire, UK

The drive to categorise kinds of intelligence and better recognise those of other animals is an important one. However, I don't think the periodic table analogy is good. It isn't obvious that there would be an underlying structure akin to that imposed by quantum mechanics on the elements.

Ute Eberle writes that looking for intelligence in the animal kingdom might be a comfort, given the "collective stupidity" of humanity, but misses a critical point. The animal intelligences that are becoming recognised are adept in the fields of problem solving, where humans still excel. The greatest examples of human stupidity are found in different areas – to generalise wildly, those of morality and ethics.

Still wrestling with the meaty issue

Letters, 14 May

From Philip Belben, Nettlebridge, Somerset, UK

Helen Senior is right to say we need a new name for "lab-grown meat", but I disagree that existing terms are "unscientific" or that "synthetic foodstuffs" would be a better term. These foods are grown from animal cells cultured in a facility (currently a laboratory, but in future, probably a factory). They are therefore arguably "animal flesh", but hardly "synthetic".

New inventions often face this problem. When a new term is needed, either a new word is coined, like automobile or flashlight, or an existing word is co-opted, like car or torch. If confusion arises with other uses of the word, a qualifier is added: motor car, or electric torch. This is what is currently being done with "lab-grown meat" – and it is the accuracy of "lab-grown" that is questionable, not the word "meat".

Retune to escape the lab coats and chalkboards

14 May, p 28

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

US-based columnist Chanda Prescod-Weinstein laments the over-representation of science on TV as people in lab coats and chalkboards full of equations.

I can think of more than a dozen scientists who regularly appear on UK television screens presenting the subject in highly accessible and enjoyable formats. Perhaps she should try what is on offer on this side of the pond.

Undergraduates are the modern lab rats

Letters, 23 April

From Steve Powell, Hursley, Hampshire, UK

Ingrid Newkirk writes regarding the "Emotional touch" part of your look at chemical haptics (19 March, p 46), and suggests that in a study of stroking, rather than using rats, it would have been better to find students to test the ideas on. However, they may not be a much better choice for this.

So many studies subject undergraduates to mental or physical experimentation in the mistaken belief that it will lead to insights into the general human condition. Nothing could be further from the truth. It has even been suggested that over-reliance on this unrepresentative group means modern psychology is, in truth, merely the study of the undergraduate under duress.

Should we allow mining of the ocean beds?

23 April, p 38

From Simon Stocker, London, UK

In your look at the "blue acceleration", the ramping up of exploitation of the oceans, it seemed to me to be a forgone conclusion that we will raid the deep oceans for minerals and strip the seas of fish and anything else we can get our hands on, regardless of the consequences.

The banks and big business are gagging to get going with the project, the argument being that we need the minerals to power the green economy.

We may well end up with a green economy for the small number of rich people who continue to make such demands of the planet, but it will probably spell disaster for the wider environment and the majority of people whose demands are not met and never have been.

From William Hughes-Games, Waipara, New Zealand

Nodule mining on the seabed may be possible with negligible damage and some surprising upsides. The devil is in the detail. Organic "snow" raised by mining crawlers must all be sucked to the surface and not allowed to smother the seabed. Large areas must also be left unmined to reseed the mined areas.

Among possible positive impacts, mined areas may become homes to pioneer species, actually increasing the biodiversity of the abyssal plains.

Keep yourself warm with a house full of books

Letters, 14 May

From Malcolm Bacchus, London, UK

Barry Cash wonders if he could insulate the solid walls of his house by attaching old clothes in plastic bottles to the outside.

Any suggestion – and many professional solutions – for such external wall insulation will look awful. Internal wall insulation is better, but can still ruin the interior appearance of properties.

There is only one perfect solution. Bookcases full of books. These insulate, look lovely and, better still, have a practical use. ▮

For the record

- **The president of El Salvador is Nayib Bukele (14 May, p 12)**
- **The endangered vaquita porpoise lives in the Gulf of California (14 May, p 21)**

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New Scientist Live

Don't miss Seirian Sumner talking about why wasps matter at New Scientist Live on 8 October
newscientistlive.com

Why wasps need more love

An exuberant and authoritative book puts wasps in their rightful place – at the centre of research, says **Simon Ings**

Book
Endless Forms: The secret world of wasps
Seirian Sumner
William Collins

"It is almost impossible to walk into a bookshop these days and not bump into a beautiful book about bees," Seirian Sumner grumbles in her lively and intermittently stomach-churning new book, *Endless Forms*. The London-based behavioural ecologist has reached "peak bee". What are bees, anyway, she writes, but wasps that have forgotten how to hunt? The "original bee" was a solitary wasp that turned vegetarian, just as the "first ant" was a wasp that lost its wings.

Wasps are where the scientific action is. Why, there are more distinct species of wasps than there are beetles. And did you know, asks Sumner, about the swarming wasps in South America that build colonies looking "like air balloons, exotic fruits, gourds, cowpats, lumps of mud, Roman vases and even chamberpots"? Or that the study of wasp venom is helping us understand the more severe symptoms presented by covid-19? And just think, the familiar yellowjacket (*Vespula*) that terrorises our picnics can discriminate between similar-looking human faces.

CREDIT HERE

A yellow-legged Asian hornet, flying in Jakarta, Indonesia

Sumner dares us to pause in wonderment. Behold the hyperparasitoids: micro-wasps that live on other parasitoid wasps, which live inside caterpillars, eating them from the inside out. Savour the chemical cocktail of toxins, enzymes and amines with which the solitary hunting wasp paralyses, cleanses and preserves prey 15 times its body weight, forming "a helpless but healthy sack of living nutrients", Sumner writes. Admire its gleaming, weaponised ovipositor.

The odd thing about wasps isn't that we steer clear of them, it is that we have learned so recently to ignore them. Much of the foundational learning offered up in this dense, anecdotal labour of love is drawn from researchers active at the latter end of the 19th century.

"What lessons can we not learn from her transcendental chemistry?" exclaimed French doctor and naturalist Jean-Marie Léon Dufour, contemplating a wasp's suspiciously fresh-looking, but weeks-old, beetle victims. "How immensely superior to our own pickling-processes is that of the wasp!"

With a level of glee last evinced by the child who urged you to put your hand in that hollow tree trunk, Sumner guides us through the evolution of hymenopteran sociality. Wasp societies represent the first stages in the evolution of altruism. Most small-colonied wasps follow a simple rule of succession: the older a female is, the closer it comes to being crowned queen.

In more complex wasp societies, aggression is the norm, as rival nestmates bite and sting each other to death. This correlation between social complexity and violence isn't reassuring. I now find myself looking askance at those highly social bees.

Endless Forms is a garrulous, generous survey of its field. I can't wait to read selected passages to my children. ▮

Simon Ings is a writer based in London

When we can talk to the animals

Radio
The Dolittle Machine
Loftus Media
BBC Radio 4, 9pm BST on 30 May
BBC Sounds

SUPPOSE we invent a translation device that enables us to talk with animals – and hear their replies. This could be good for the planet, especially if we learned to say "sorry" to the species we have pushed close to extinction. It would definitely be good for us, says writer Matthew de Abaitua, who presents this clever speculation about how artificial intelligence might help us understand animal languages.

No two species experience the world in the same way, so if animals have language at all, they are talking and thinking about different worlds. How, then, can translation progress?

We already use machine-learning algorithms to translate between human languages. These spot words that tend to appear next to each other. By matching these patterns across languages, a machine begins to translate. The hope is that by listening to squeaks and songs, the same method may spot common terms in the languages of other species.

The differences in life experience between species are huge. A loquacious bat may struggle to describe echolocation to a human. A dolphin may not be able to offer a bat much insight into the experience of an animal whose breath is the outcome of a conscious decision. A human may struggle to explain taxes to a dolphin. But bat, dolphin and human may still be able to talk about common experiences like hunger, danger and family.

The Dolittle Machine is a superb distillation of a complex area. The possibilities it conjures leave us feeling a bit less alone. ▮ Simon Ings

After the Romans

Who were the Anglo-Saxons? A smart, humane book digs deep to re-examine their true origins, finds **Michael Marshall**

Book

Buried: An alternative history of the first millennium in Britain
Alice Roberts
Simon & Schuster

FEW groups of people exert more power on English imagination than the Anglo-Saxons. They first appear in the historical record in the 1st millennium AD, in the wake of the Roman Empire's retreat from Britain, and historians have seen them as playing a central role in the emergence of medieval English society. But were they a group who invaded Britain from mainland Europe? Or might there be another explanation hidden in the record?

Biological anthropologist Alice Roberts can't fully answer this question in her engaging new book *Buried*, but it becomes clear this is for reasons beyond her control. She has become arguably the UK's most famous archaeologist thanks to her extensive television work, and that experience shines through in her clear, richly detailed writing.

Buried is a loose sequel to last year's *Ancestors*. In both, Roberts devotes each chapter to a grave, the people and artefacts found in it and what it might tell us about ancient British peoples. But where *Ancestors* focused on prehistoric burials, often many thousands of years old, *Buried* is about the 1st millennium AD: the period when the Roman conquest failed and Britain was then transformed.

Writing scientifically about graves and corpses is a challenge, but Roberts threads the needle beautifully. She is rigorous and sceptical, but never lets that stop her from empathising with the people concerned. That human kindness is essential, because some of the stories revealed by the burials are upsetting. Roberts even goes so far as to gently suggest that some readers might want to skip chapter two, which deals with the discovery of a baby's bones in the grounds of what was once a Roman villa.

In the final chapter, Roberts knits her stories together into a larger narrative about the post-Roman period in Britain. Her central concern is the pervasive idea, taken from a few rather partial historical sources, that Anglo-Saxons invaded Britain from what is now Germany.

> "Historians have seen the Anglo-Saxons as central to the emergence of medieval English society"

The evidence for a cultural shift is overwhelming, but such shifts can come about by means other than violent conquest. The alternative is that there were a number of cultural behaviours that emerged in Europe, which we now call Anglo-Saxon. These were then transmitted to Britain by word of mouth without the need for migration. History being messy, it could also, have been caused by a bit of both.

Roberts clearly had big plans on this front. She explains how she sent bone samples from the graves to the Thousand Ancient Genomes project, set up in 2019 by geneticist Pontus Skoglund at the Francis Crick Institute in London. But when the covid-19 pandemic kicked off, the institute stopped all of its non-coronavirus work, so Roberts didn't have the genetic data that would have put her ideas to the test.

Fortunately, even without the pay-off of the genetics, *Buried* more than earns its keep. Roberts's nuanced discussions of the burials fuse a half-dozen scholarly fields without any sense of the narrative lurching: any switches between talk of bone shapes and early medieval manuscripts are handled deftly.

It reminded me of Oliver Sacks's wonderful books describing neuropsychiatric conditions, which combine rigorous analysis of the underlying biology with a tender humanism and empathy. If anything, what Roberts is doing is harder because she can't talk to the people about whom she writes. ▮

Michael Marshall is a science writer and author of *The Genesis Quest*

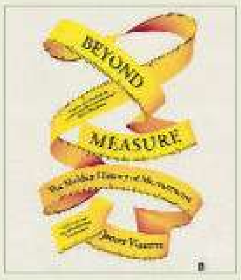
The skeleton of an Anglo-Saxon male, found at the Barrow Clump burial site on Salisbury Plain, UK

JAMIE WISEMAN/SHUTTERSTOCK

Don't miss

Visit

Journeys across Afro-futurism traces Black futures through the medium of film, featuring Sun Ra, Ornette Coleman, Nyokabi Gethaiga and others. At the Barbican Centre, London, from 2 to 30 June.



Read

Beyond Measure documents humanity's attempts to claw dependable truths from a chaotic universe. James Vincent's gripping story of how and why we measure just about everything, from radiation to happiness, is published on 2 June.

Watch

The Orville begins its third season. Starring Adrianne Palicki as Commander Kelly Grayson and Seth MacFarlane as Captain Ed Mercer, they're out to find strange new ways of sending up *Star Trek*. On Hulu (US) from 2 June.

T-B: ORNETTE MADE IN AMERICA; MICHAEL DESMOND/HULU

The games column

Imagination rules This lo-fi role-playing game set aboard a decrepit space station sees you play as a Sleeper, a human mind in a robot body. Exploring multiple storylines helps you create a fantastic sci-fi tapestry, says **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

Game

Citizen Sleeper

Jump Over the Age

PC, Xbox One and Series X/S, Nintendo Switch

Jacob also recommends...

Games

orbit.industries

LAB132

PC, PlayStation 4 and 5, Xbox One and Series X/S, Nintendo Switch

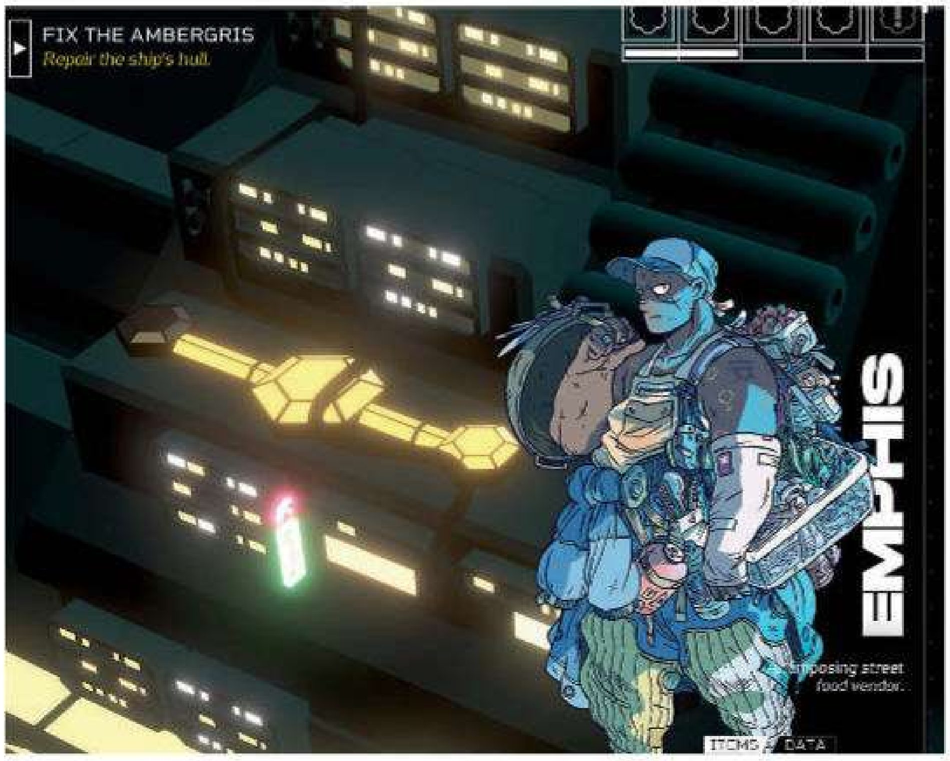
At the opposite end of the emotional spectrum to Citizen Sleeper, orbit.industries *tasks you with building a space station.*

Tharsis

Choice Provisions

PC, PlayStation 4, Nintendo Switch

Inspired by board games, Tharsis *places you in charge of a failing mission to Mars, using a limited pool of dice to tackle emergencies.*



FELLOW TRAVELLER GAMES

In *Citizen Sleeper*, you work on a decaying space station called Erlin's Eye

IN ADDITION to being *New Scientist*'s resident video game guru, I am a big fan of tabletop role-playing games (TTRPGs) like *Dungeons & Dragons*. With no need to conjure up graphics or touch a line of code, in a TTRPG, you are limited only by your shared imagination.

Pleasingly, video games are increasingly borrowing ideas from TTRPGs. The latest is *Citizen Sleeper*, a lo-fi cyberpunk RPG set aboard a dilapidated space station called Erlin's Eye. You play as a Sleeper, a human mind in a robot body. Wiped of their original memories, Sleepers usually serve as slaves for the megacorp that owns them, but you have escaped.

Like a TTRPG, much of the game takes place in your imagination. You don't navigate a 3D world, but interact through location points dotted around a map of the space station. These might present you with the chance for conversations, told through text in a similar way to *Disco Elysium*, as well as charming character pictures. Or you could be given a choice of tasks to perform in order to achieve your goals.

The first priority in the game is survival. Your robot body is built to slowly decay unless you can get the treatment provided by the megacorps; finding an alternative supplier is an early goal. You also need food for power, and the only way to pay for it is by earning cryptocurrency through jobs such as bartending or shifting packages.

> **"The game lets you go back to just before the end and make different decisions, but it felt wrong to try"**

The game operates in cycles, the equivalent of a day on the space station. At the start of each cycle, the state of your body and hunger determine the number of dice you receive, up to a total of five. These have random values from 1 to 6 and can be used to carry out actions like working or exploring the space station. Once you have used all your dice, that is it until a new cycle starts.

Longer goals are possible thanks to clocks at each location, a game mechanic popularised by the TTRPG *Blades in the Dark*. These are circles divided into segments, with more difficult or lengthy tasks corresponding to more segments. Tending bar might fill up a clock that allows you to make friends with the owner, say.

As you progress, your options explode to the point where you will never manage to do everything, but juggling clocks allows you to pursue the stories and characters that most interest you, weaving a fantastic sci-fi tapestry. The game suggests some goals, but I found it more enjoyable to let my interests guide me.

My personal narrative was incredibly moving. Having got myself to a position where I could survive happily from cycle to cycle, I split my time between working on building a colony ship, where I met a man and his daughter, and trying to grow a ship repair business with a partner.

A twist in the first story left me distraught and searching for answers, to the point where I didn't devote enough time to the business. With the clock ticking on a huge repair job, I realised the work I had put in would be wasted because I couldn't finish it. Worried I had failed in the game, a risky, last-minute chance for redemption appeared, leading to a satisfying and emotional ending.

Once the credits roll, the game lets you go back to just before the end and make different decisions. I still had much of the station to explore, but it felt wrong to try those alternatives. Why choose at all if you don't step away from one path to another? *Citizen Sleeper* let me tell my story, and I wouldn't want to change it. ▮

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The nuclear option

An indispensable way to meet our climate goals or unnecessary and unconscionable? What should we think about nuclear energy, asks **Michael Brooks**

LUXEMBOURG'S energy minister described it as "a provocation". Austria declared it would "destroy the future of our children". And climate activist Greta Thunberg railed against "fake climate action".

Their anger was directed at a draft regulation from the European Commission, released earlier this year, that would designate nuclear power as a "green" source of electricity and thereby make nuclear projects eligible for favourable financial terms. France, Europe's leading atomic state with 56 active reactors and more planned, was unperturbed.

Such are the fault lines. "The debate over whether we need nuclear power is very polarised," says M. V. Ramana at the University of British Columbia in Vancouver.

For many, it is too dangerous and expensive. Others say that nuclear power is a reliable source of clean energy – indispensable if we want to meet increasingly ambitious climate goals. In its 2021 report, the Intergovernmental Panel on Climate Change (IPCC) included nuclear-generated electricity in all four of its suggested pathways to net-zero carbon emissions by 2030. Add in fresh concerns over energy security, and it is no surprise new life has been breathed into an old question: do we really need nuclear energy?

In the fog of claim and counterclaim, it can be hard to know what to think. Arguments over nuclear seem to generate a lot more heat than light. However, now more than ever we need answers to key questions: Is nuclear prohibitively costly? Can we build it quickly enough? Is the waste problem a deal-breaker? And, ultimately, is there a better way to meet demand for carbon-free electricity when renewable energy sources fall short?

Nuclear has been unpopular for decades, and existing anxieties were stoked anew when a tsunami hit the Fukushima plant in Japan in 2011. The country suspended all 50 of its reactors and several other nations delayed or cancelled plans to build new ones. Germany decided to phase out nuclear powall together.

That seemed to make economic sense too, at the time. Gas was cheap and the cost of renewables was tumbling fast. It also meant no more radioactive waste (see "The waste problem", page 42). The conflict over nuclear's value in the fight against climate change looked settled, as demonstrated by the fact that the number of active reactors has hardly changed since the 1980s and looks set to drop (see "What if nuclear fades away?", page 40).

In 2022, though, things look a bit different. True, Germany is set to follow through on phasing out nuclear even as Europe struggles with energy shortages resulting from Russia's invasion of Ukraine. But France and Finland will start producing electricity at new, more advanced reactors, the first of their kind in the West. The US is building two new reactors in Georgia. And China, the world's biggest carbon emitter, is committing $440 billion to building at least 150 reactors over the next 15 years.

The IPCC would approve. The International Energy Agency (IEA), too, insists that nuclear must be part of the solution to the climate crisis. In its 2021 road map to net zero, the IEA said that by 2050 "almost 90 per cent of electricity generation comes from renewable sources, with wind and solar together accounting for almost 70 per cent" and "most of the remainder comes from nuclear power".

The main reason the IPCC and the IEA consider nuclear indispensable is that the most abundant sources of renewable energy are variable: the sun sets, the wind drops and the seasons vary every year. "You only get energy from them 20 to 30 per cent of the time, and not at the right time," says Jacopo Buongiorno, director of the Center for Advanced Nuclear Energy Systems at the Massachusetts Institute of Technology (MIT). To get around that, you need a means of storing wind and solar energy when it is in excess to fill any gaps, which

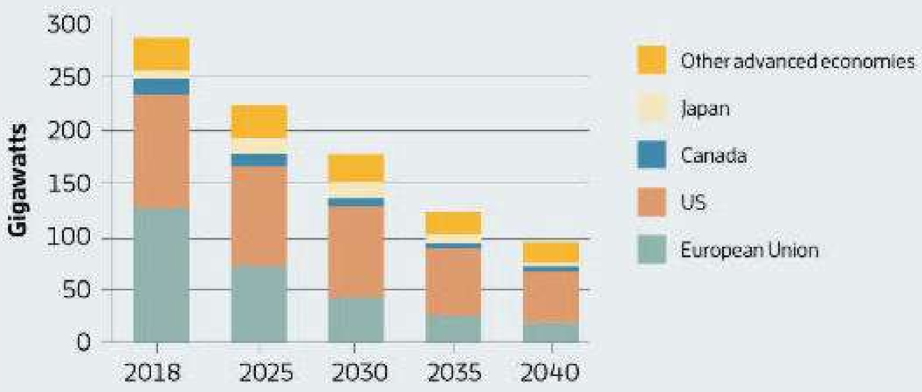
›

IRENA GAJIC

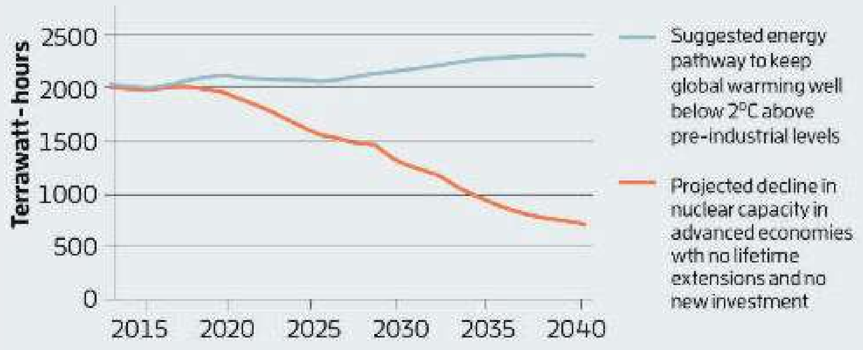
What if nuclear fades away?

In 2018, nuclear energy was the second-largest source of low-carbon electricity, providing 10 per cent of all electricity globally. That will drop without investment in new nuclear plants, arguably making it harder to reduce carbon emissions before it is too late.

Projections from the International Energy Association (IEA) suggest that without fresh investment, nuclear capacity in advanced economies will decline by two-thirds by 2040



Without extending the operational life of existing nuclear plants or building new ones, the IEA predicts a shortfall in electricity generation will emerge in advanced economies. The question then becomes whether or not renewables can plug that gap



SOURCE: IEA.ORG/REPORTS/NUCLEAR-POWER-IN-A-CLEAN-ENERGY-SYSTEM

makes the renewables package much more expensive than advertised. "You can't just look at the cost of a single kilowatt-hour; you have to look at the cost of the whole system," says Buongiorno. "That aggregate cost is much higher than if you have a little bit of dispatchable low-carbon capacity."

A "dispatchable" supply is one that can be ramped up and down as required or at least fed into the grid at will. We can no longer rely on coal or gas for this, and many experts argue that nuclear is the most sensible alternative. "All the serious analyses – from MIT, Stanford and the IPCC for example – show that the path to deep decarbonisation, with the least cost and shortest time, has renewables, a little bit of storage and quite a bit of dispatchable carbon-free capacity, like nuclear," says Buongiorno.

Some would question the description of nuclear as "carbon-free". In construction, nuclear plants require vast amounts of concrete, production of which has a hefty carbon footprint. Despite this, a 2017 study calculated nuclear's carbon emissions per unit of energy generated as equivalent to wind and lower than solar power. "I can see why the IPCC put nuclear power in a category of low-carbon," says Antony Froggatt at the UK policy research institute Chatham House.

Not everyone agrees. When you take into account the 10 to 21-year time lag between starting work on a nuclear project and a reactor becoming operational, the numbers change, according to Mark Z. Jacobson at Stanford University in California. We need another supply of energy for all that time, he argues, and its carbon footprint should be pinned on nuclear. "The carbon dioxide emissions of nuclear are nine to 37 times those of wind power

TVO

Olkiluoto-3, a new nuclear reactor in Finland

THE WEAPONS CONNECTION

Russia's invasion of Ukraine reminds us that we live in a nuclear-armed world. Nuclear weapons are a part of the global calculus of peace, and they have to be maintained and positioned ready for use to serve their purpose as a deterrent. All of which requires nuclear know-how, often maintained through civil nuclear-power programmes.

Most governments keep quiet about this interplay, but US president Barack Obama's former energy secretary Ernest Moniz has made the link explicit. In 2017, Moniz's think tank, the Energy Futures Initiative, issued a report entitled *The U.S. Nuclear Energy Enterprise: A key national security enabler*. It said that "a strong domestic supply chain is needed to provide for nuclear Navy requirements. This supply chain has an inherent and very strong overlap with the commercial nuclear energy sector and has a strong presence in states with commercial nuclear power plants." France's president Emmanuel Macron put it even more succinctly in 2020: "Without civilian nuclear, no military nuclear, without military nuclear, no civilian nuclear."

If the pool of experts gets small, civil and military nuclear can even end up competing. Rolls-Royce, the UK government's choice for its new small modular reactor programme is also the UK's only naval nuclear propulsion supplier. In a 2006 memorandum to the UK parliament's Defence Committee, it complained that the depletion of civil nuclear skills had "reduced the support network available to the military programmes". The firm said building new civil nuclear power plants would put "considerable pressure on the UK's remaining [nuclear] skills capacity".

So the decision about whether to invest in civil nuclear power isn't as simple as "does it provide marketable electricity?". However you feel about nuclear weapons, a dearth of relevant expertise isn't conducive to a good night's sleep.

per unit of electricity generated," he says.

There are other wrinkles, too. One is that investment in nuclear seems to reduce commitment to curbing carbon emissions. A 2020 study of 123 countries over 25 years showed that "larger-scale national nuclear attachments do not tend to associate with significantly lower carbon emissions, while renewables do". France was 4 percentage points behind its target for renewable generation in 2020, while almost all other European Union countries were way ahead of theirs. Germany's nuclear phase-out induced investment in wind and solar, and the country was 1 per cent ahead of its 2020 target, despite using fossil fuels to plug its "energy gap" as reactors shut.

Where critics say nuclear can't possibly compete with renewables is in how quickly newly commissioned installations can begin to deliver. "It takes too long to site and build nuclear reactors, especially compared to solar and wind installations," says Kate Brown, who researches technology and society at MIT.

That is because building new nuclear plants is hard. France's Flamanville-3 reactor is a decade behind schedule. Finland's Olkiluoto-3 turned on partially this year, but it was meant to be finished in 2009. Since 2011, ground has been broken on the construction of 57 new nuclear reactors globally. By 2021, just 15 had started to deliver electricity.

Despite these problems, Buongiorno is "somewhat optimistic" about new nuclear. "There are reasons to believe that the next wave of construction might be a little bit better," he says – namely a series of studies into what went wrong with previous projects. Moreover, countries such as South Korea, China, India and Russia routinely deliver nuclear power plants on time and within budget. And some claim that new reactor technologies will make a difference to the time lag problem (see "Nuclear but nimble", right).

We now know that integrating the designers and builders from the start, for instance, makes an enormous difference to the delay and cost escalation down the line. These insights, says Buongiorno, will get us new nuclear in time to make an impact on carbon emissions. "Things are certainly tight, but they're tight for all technologies," he says. "It has been very hard to scale up renewables as well."

The trouble with that argument is that we can scale up renewables faster than nuclear, says Froggatt. "The next decade is crucial to meet global greenhouse gas targets," he says. There needs to be a 45 per cent reduction in emissions by 2030 to keep global warming below 1.5°C above pre-industrial levels, but "if a reactor is not currently under planning, it will not be completed by 2030", he says. "So nuclear power will only, at best, very marginally increase its contribution to the global energy mix. Therefore, accelerating global emissions reduction by 2030 can't be with nuclear power."

Others are thinking longer-term, though. They say that acting now to establish nuclear in the energy mix by 2050, will go a long way to ensuring that we can sustain a low-carbon energy sector through the rest of this century.

Whatever the deadline, investing in new nuclear will require deep pockets. When construction started on Flamanville-3, it was expected to cost €3.3 billion. The latest ›

NUCLEAR BUT NIMBLE

While many countries persist with large and difficult-to-build full-scale nuclear reactors, there is now a less cumbersome option. Small modular reactors (SMRs) are entirely or partially assembled in factories and brought to site on the back of a lorry. The idea is that although they have a relatively low energy output, SMRs are faster and cheaper to build. "Overall, the scope of these projects is going to be more manageable than traditional multi-billiondollar, 10-year projects," says Jacopo Buongiorno, director of the Center for Advanced Nuclear Energy Systems at the Massachusetts Institute of Technology.

In which case, SMRs could change the calculus regarding the cost of nuclear energy (see main story). The trouble is that no commercial SMRs are up and running. "The 'new reactors' don't exist yet, so we have no idea what their costs, time requirements, waste risks, meltdown risks and weapons proliferation risks will be," says Mark Z. Jacobson at Stanford University in California.

There are efforts to get SMRs off the drawing board. In the UK, Rolls-Royce is leading a consortium to produce one based on the "pressurised water reactor" (PWR) concept originally designed for military aircraft carriers and submarines, and subsequently used in a large proportion of the world's nuclear power plants. Meanwhile, US start-up NuScale, which is also using a modified PWR design, has received regulatory approval.

There are plenty of other SMR designs in development, too. US businessmen Bill Gates and Warren Buffett are putting money into TerraPower, for instance, whose design involves a sodium-cooled reactor. Pending regulatory approval, the aim is to begin construction of the first plant in Wyoming, with energy being delivered in 2030.

But here's the rub: the end of the decade is the finishing post for most SMR projects. This is too late for helping with 2030 emissions targets. And the finishing post tends to move, says M. V. Ramana at the University of British Columbia in Vancouver. "At this point, NuScale is about 15 years behind its promised schedule. It started in 2008, they were hoping to generate power by 2015 or 2016. Now they are talking about 2029 or 2030." The upshot is that it is still too early to say if SMRs will make a substantial difference to arguments over nuclear power.

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Construction underway at Hinkley Point C nuclear power station, UK

EDF

> **“We have to be careful: energy cost forecasts are inherently unreliable”**

estimate is €12.4 billion. The price tag for the two new US reactors has risen from $14 billion to $29 billion. But maybe Buongiorno’s optimism about the industry learning from the past will be validated. Projections do show that the cost of nuclear-generated electricity is falling: according to the IEA, it is expected to drop by 7 per cent between 2020 and 2050. But the cost of renewables is expected to fall faster: onshore wind by 14 per cent, offshore wind by 66 per cent and solar by 58 per cent. In some markets, investors in nuclear could struggle to get their money back.

We have to be careful with all such figures, warns Ramana. Energy cost forecasts are inherently unreliable. But even if we assume that cost comparisons will make it hard to justify using anything other than a minimal amount of nuclear power in the future, proponents say that is all we need.

Do we even need that though? These days, some experts argue that the intermittency problem of renewables can be solved without nuclear. “Baseload, in the sense of needing something that generates 24/7, is outdated,” says Jim Watson, an energy policy researcher at University College London. “As we get more renewables, we’re going to need more flexibility, whether from managing demand, from storage, or from connecting to neighbouring countries.”

Grid operators already pay large companies to reduce their electricity use at times of peak demand, and there are moves to do the same in domestic settings: we could pay people to store energy in electric vehicle batteries and draw on it when the vehicles aren’t in use. Industrial-scale battery storage is also coming online. This tends to be a short-term solution, but there are longer-term options such as pumped hydropower, which uses excess energy to pump water uphill, ready to run through power turbines. And then there are “continental supergrids” – sprawling energy networks that shunt power thousands of kilometres – which would mean you can always get electricity, wherever it is generated.

It remains to be seen if such innovations can pick up the slack. And herein lies the problem when it comes to making your mind up on nuclear: so much depends on things we don’t know for sure. On the one hand, why bother with it, given its drawbacks, if we can meet our net-zero targets with nothing but renewables? “I tend to believe we can do 100 per cent renewables,” says Ramana. On the other hand, why put all your eggs in one basket? “It’s not an either-or situation: we’ve got to do them both,” says Buongiorno. Even among those with all the facts at their disposal, those fault lines remain. Add in the fact that nuclear weapons make things even more complicated (see “The weapons connection”, page 40), and it is clear why nothing is clear. Whatever call we make, some people will say it is wrong. The only thing we can do is be sure that we don’t make the call too late. ■

Michael Brooks is a *New Scientist* consultant. His latest book is *The Art of More: How mathematics created civilisation*

THE WASTE PROBLEM

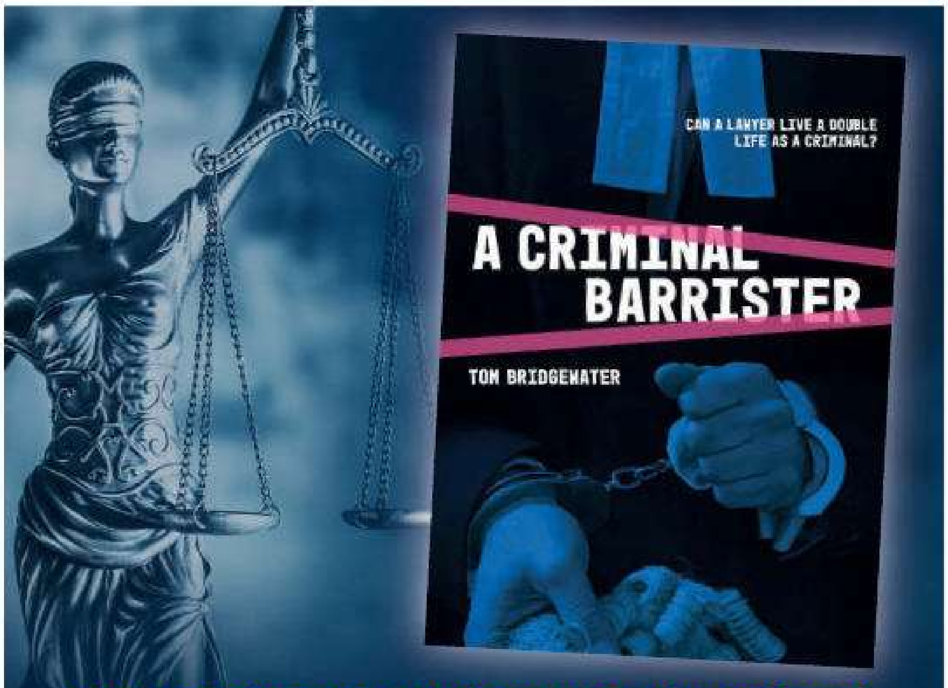
Radioactive contamination from accidents and waste from spent nuclear reactors are often cited as key reasons to shun nuclear energy. If there are other routes to net-zero emissions, the argument goes, why saddle future generations with these toxic legacies.

That problem isn’t going away. There are no neat solutions, even if Finland has begun construction of an underground repository for waste that the UN’s International Atomic Energy Agency hailed as a “game changer”. But let’s be honest: waste storage and contamination have yet to stop the world turning. The climate crisis requires urgent solutions and nuclear could be part of that, so doesn’t it make sense to set aside the waste issue?

It isn’t as if renewables are guilt-free. Wind turbine blades last for about 20 years, but they can’t all be recycled at the end of their life. At the moment, many of them go into landfill. When solar panels reach the end of their lives, they are arguably worse, because they contain toxic chemicals such as cadmium and lead. The International Renewable Energy Agency has predicted that the planet will be littered with up to 78 million tonnes of solar panel waste by 2050.

What’s more, modern nuclear reactors should create less of a waste problem than before. At Hinkley Point in the UK, new reactors will use 17 per cent less uranium and produce almost a third less long-lived radioactive trash than today’s water-cooled reactors. The small modular reactors coming off the drawing boards will also produce less waste than other reactors.

This is something to celebrate, surely? Not according to Mark Z. Jacobson at Stanford University in California. “Those that produce less waste will result in greater weapons proliferation risk since waste is reduced by refining uranium to a greater degree, and that results in closer to weapons-grade uranium,” he says. As ever with nuclear energy, it is more complicated than it first appears.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IN ASSOCIATION WITH srg

What causes what?

A new way to look at cause and effect could transform our view of biology – and shed new light on the question of free will, finds **Philip Ball**

THERE are seconds left on the clock, and the score is 0-0. Suddenly, a midfielder seizes possession and makes a perfect defence-splitting pass, before the striker slots the ball into the bottom corner to win the game. The moment will be scrutinised ad nauseam in the post-match analysis. But can anyone really say why the winners won?

One thing is for sure, precious few would attribute the victory to quantum mechanics. But isn't that, in the end, all there is? A physicist might claim that to explain what happens to a football when it is kicked, the interactions of quantum particles are all you need. But they would admit that, as with many things we seek to understand, there is too much going on at the particle-level description to extract real understanding.

Identifying what causes what in complex systems is the aim of much of science. Although we have made amazing progress by breaking things down into ever smaller components, this "reductionist" approach has limits. From the role of genetics in disease to how brains produce consciousness, we often struggle to explain large-scale phenomena from microscale behaviour.

Now, some researchers are suggesting we should zoom out and look at the bigger picture. Having created a new way to measure causation, they claim that in many cases the causes of things are found at the more coarse-grained levels of a system. If they are right, this new approach could reveal fresh insights about biological systems and new ways to intervene – to prevent disease, say. It could even shed light on the contentious issue of free will, namely whether it exists.

The problem with the reductionist approach is apparent in many fields of science, but let's take applied genetics. Time and again, gene variants associated with a particular disease or trait are hunted down, only to find that knocking that gene out of action makes no apparent difference. The common explanation is that the causal pathway from gene to trait is tangled, meandering among a whole web of many gene interactions.

The alternative explanation is that the real cause of the disease emerges only at a higher level. This idea is called causal emergence. It defies the intuition behind reductionism, and the assumption that a cause can't simply appear at one scale unless it is inherent in microcauses at finer scales.

Higher level

The reductionist approach of unpicking complex problems into their constituent parts has often been fantastically useful. We can understand a lot in biology from what enzymes and genes do, and the properties of materials can often be rationalised from how their constituent atoms and molecules behave. Such successes have left some researchers suspicious of causal emergence.

"Most people agree that there is causation at the macro level," says neuroscientist Larissa Albantakis at the University of Wisconsin-Madison. "But they also insist that all the macroscale causation is fully reducible to the microscale causation."

Neuroscientists Erik Hoel at Tufts University in Massachusetts and Renzo Comolatti at the University of Milan in Italy are seeking to work out if causal emergence really exists and if so, how we can identify it and use it. "We want to take causation from being a philosophical question to being an applied scientific one," says Hoel.

The issue is particularly pertinent to neuroscientists. "The first thing you want to know is, what scales should I probe to get relevant information to understand behaviour?" says Hoel. "There's not really a good scientific way of answering that."

Mental phenomena are evidently produced by complex networks of neurons, but for some brain researchers, the answer is still to start at small scales: to try to understand brain function on the basis of how the neurons interact. The European Union-funded Human Brain Project set out to map every one of the brain's 86 billion neurons, in order to simulate a brain on a computer. But will that be helpful?

Some think not: all the details will just obscure the big picture, they say. After all, you wouldn't learn much about how an internal combustion engine works by making an atomic-scale computer simulation of one. But if you stick with a coarse-grained description, with pistons and crankshafts and so on, is that just a convenient way of parcelling up all the atomic-scale information into a package that is easier to understand?

The default assumption is that all the causal action still happens at the microscopic level, says Hoel, but we simply "lack the computing power to model all the microphysical details, and that's why we fixate on particular scales". "Causal emergence," he says, "is an alternative to this null hypothesis." It says that, for some complex systems, looking at a coarse-

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KYLE ELLINGSON

Ice creams and sunburn may be correlated, but one does not cause the other

MARTIN PARR/MAGNUM PHOTOS

> **"Causal emergence lets us escape being ruled by quantum mechanics"**

grained picture isn't just tantamount to data compression that dispenses with some detail. Instead, it is proposing that there can be more causal clout at these higher levels than there is below. Hoel reckons he can prove it.

To do so, he first had to establish a method for identifying the cause of an effect. It isn't enough to find a correlation between one state of affairs and another: correlation isn't causation, as the saying goes. Just because the number of people eating ice creams correlates with the number who get sunburn, it doesn't mean that one causes the other. Various measures of causation have been proposed to try to get to the root of such correlations and see if they can be considered causative.

In 2013, Hoel, working with Albantakis and fellow neuroscientist Giulio Tononi, also at the University of Wisconsin-Madison, introduced a new way to do this, using a measure called "effective information". This is based on how tightly a scenario constrains the past causes that could have produced it (the cause coefficient) and the constraints on possible future effects (the effect coefficient). For example, how many other configurations of football players would have allowed that midfielder to release the striker into space, and how many other outcomes could have come from the position of the players as it was just before the goal was scored? If the system is really noisy and random, both coefficients are zero; if it works like deterministic clockwork, they are both 1.

Effective information thus serves as a proxy measure of causal power. By measuring and comparing it at different scales in simple model systems, including a neural-like system, Hoel and his colleagues demonstrated that there could be more causation coming from the macro than from the micro levels: in other words, causal emergence.

Quantifying causation

It is possible that this result might have been a quirk of the models they used, or of their definition of effective information as a measure of causation. But Hoel and Comolatti have now investigated more than a dozen different measures of causation, proposed by researchers in fields including philosophy, statistics, genetics and psychology to understand the roots of complex behaviour. In all cases, they saw some form of causal emergence. It would be an almighty coincidence, Hoel says, if all these different schemes just happened to show such behaviour by accident.

The analysis helped the duo to establish what counts as a cause. We might be more inclined to regard something as a genuine cause if its existence is sufficient to bring about the result in question. Does eating ice cream on its own guarantee a high chance of sunburn, for example? Obviously not. We can also assess causation on the basis of necessity: does increased sunburn only happen if more ice creams are consumed, and not otherwise? Again, evidently not: if the ice-cream seller takes a day off on a sunny day, sunburn can still happen. Causation can thus be quantified in terms of the probability that a set of affairs always and only leads to an effect.

Their work has its critics. Judea Pearl, a computer scientist at the University of California, Los Angeles, says that attempts to "measure causation in the language of probabilities" are outdated. His own models simply state causal structures between adjacent components and then use these to enumerate causal influences between more distantly connected components. But Hoel says that in his latest work with Comolatti, the measures of causation they consider include such "structural causal models" too.

Their conclusion that causal emergence

really exists also finds support in recent work by physicists Marius Krumm and Markus Müller at the University of Vienna in Austria. They have argued that the behaviour of some complex systems can't be predicted by anything other than a complete replay of what all of the components do at all levels; the microscale has no special status as the fundamental origin of what happens at the larger scales. The larger scales, they say, might then constitute the real "computational source" – what you might regard as the cause – of the overall behaviour.

In the case of neuroscience, Müller says, thoughts and memories and feelings are just as much "real" causal entities as are neurons and synapses – and perhaps more important ones, because they integrate more of what goes into producing actual behaviour. "It's not the microphysics that should be considered the cause for an action, but its high-level structure." says Müller. "In this sense we agree with the idea of causal emergence ."

Causal emergence seems to also feature in the molecular workings of cells and whole organisms, and Hoel and Comolatti have an idea why. Think about a pair of heart muscle cells. They may differ in some details of which genes are active and which proteins they are producing more of at any instant, yet both remain secure in their identity as heart muscle cells – and it would be a problem if they didn't. This insensitivity to the fine details makes large-scale outcomes less fragile, says Hoel. They aren't contingent on the random "noise" that is ubiquitous in these complex systems, where, for example, protein concentrations may fluctuate wildly.

As organisms got more complex, Darwinian natural selection would therefore have favoured more causal emergence – and this is exactly what Hoel and his Tufts colleague Michael Levin have found by analysing the protein interaction networks across the tree of life. Hoel and Comolatti think that by exploiting causal emergence, biological systems gain resilience not only against noise, but also against attacks. "If a biologist could figure out what to do with a [genetic or protein] wiring diagram, so could a virus," says Hoel. Causal emergence makes the causes of behaviour cryptic, hiding it from pathogens that can only latch onto molecules.

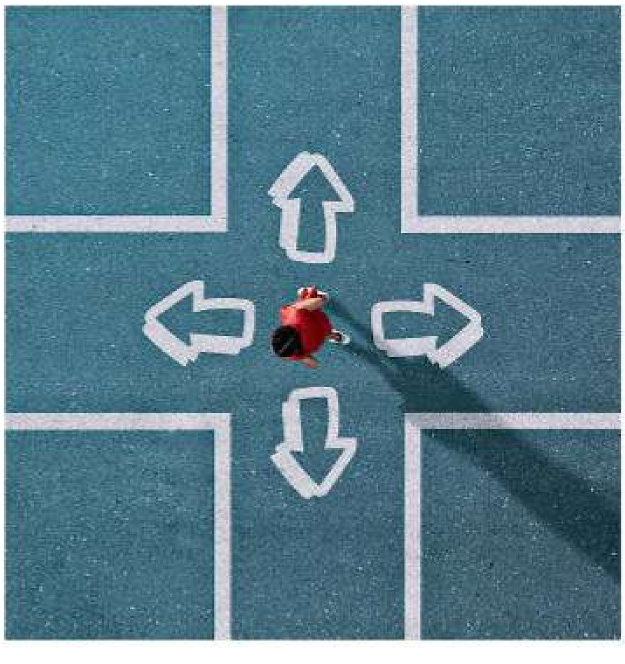
Whatever the reasons behind it, recognising causal emergence in some biological systems could offer researchers more sophisticated ways to predict and control those systems. And that could in turn lead to new and more effective medical interventions. For example, while genetic screening studies have identified many associations between variations of different genes and specific diseases, such correlations have rarely translated into cures, suggesting these correlations may not be signposts to real causal factors. Instead of assuming that specific genes need to be targeted, a treatment might need to intervene at a higher level of organisation. As a case in point, one new strategy for tackling cancer doesn't worry about which genetic mutation might have made a cell turn cancerous, but instead aims to reprogramme it at the level of the whole cell into a non-malignant state.

You decide?

Suppressing the influence of noise in biological systems may not be the only benefit causal emergence confers, says Kevin Mitchell, a neuroscientist at Trinity College Dublin, Ireland. "It's also about creating new types of information," he says. Attributing causation is, Mitchell says, also a matter of deciding which differences in outcome are meaningful and which aren't. For example, asking what made you decide to read *New Scientist* is a different causal question to asking what made you decide to read a magazine.

Which brings us to free will. Are we really free to make decisions like that anyway, or are they preordained? One common argument against the existence of free will is that atoms interact according to rigid physical laws, so the overall behaviour they give rise to can be nothing but the deterministic outcome of all their interactions. Yes, quantum mechanics creates some randomness in those interactions, but if it is random, it can't be involved in free will. With causal emergence, however, the true causes of behaviour stem from higher degrees of organisation, such as how neurons are wired, our brain states, past history and so on. That means we can meaningfully say that we – our brains, our minds – are the real cause of our behaviour.

The idea that causation occurs at higher scales suggests free will exists after all



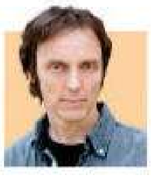
KLAUS VEDFELT/GETTY IMAGES

That is certainly how neuroscientist Anil Seth at the University of Sussex, UK, sees things. "What one calls 'real' is of course always going to be contentious, but there is no objection in my mind to treating emergent levels of description as being real," he says. We do this informally anyway: we speak of our thoughts, desires and goals. "The trick is to come up with sensible ways to identify and measure emergence," says Seth. Like Hoel and Comolatti, he is pursuing ways of doing that.

Hoel says that the work demonstrating the existence of causal emergence "completely obviates" the idea that "all the causal responsibility drains down to the lower scale". It shows that "physics is not the only science: there are real entities that do causal work at higher levels", he says – including you.

Case closed? Not quite. While Mitchell agrees that causal emergence allows us to escape being ruled by the laws of quantum mechanics, he adds that what most people mean by free will requires an additional element: the capacity for conscious reflection and deliberate choice. It may be that we experience this sense of free will in proportion to the degree to which our higher-level brain states are genuine emergent causes of behaviour. Our perception of executing voluntary actions, says Seth, "may in turn relate to volition involving a certain amount of downward causality".

In other words, you really are more than the sum of your atoms. If you think you made a choice to read this article, you probably did. ∎



Philip Ball is a science writer based in London

It can seem like a disease of the distant past, but the bacterium that causes plague never went away – and it could strike again in a new form, finds **Graham Lawton**

Return of the plague

THE onslaught, when it came, was swift and merciless. It started in Crimea in 1347 before fanning out across Europe, killing terrified and defenceless people by the million. The sickness causing all this death subsided in 1351, but returned with a vengeance a few years later. By the time the second wave had passed, more than 50 million people had died.

"It was the most important, the most impactful, the worst event that ever happened in Europe," says Alessia Masi at the Max Planck Institute for the Science of Human History in Jena, Germany. She is talking about the Black Death, a five-year outbreak of plague that, by some estimates, killed half the population of medieval Europe.

That dreaded episode is etched into our collective memory of the Middle Ages, which is perhaps why the plague feels like ancient history. But the bacterium that causes it is very much still with us, and epidemiologists are now warning that this deadliest of pathogens could yet reawaken in an even scarier guise. Far from being a spectre from the distant past, the plague could well become a disease of today, unless we start to take its threat more seriously.

To plague historians, the Black Death was merely an early chapter – albeit a particularly gory one – in a series of pandemics that ravaged western Eurasia and north Africa for the best part of five centuries. It wasn't the first of its kind. That dubious honour goes to the pandemic that broke out in Constantinople

JOE BLOSSOM/ALAMY

A worker sanitises a school in Antananarivo, Madagascar, during the plague outbreak of 2017 (below); rat traps (left) in Antananarivo's hot and crowded streets (bottom)

T-B: RIJASOLO/AFP VIA GETTY IMAGES; HENITSOA RAFALIA/ANADOLU AGENCY/GETTY IMAGES; MIHTIANDER/GETTY IMAGES

(now Istanbul, Turkey) in AD 541, which spread far and wide and lasted for more than 200 years, though the severity of this pandemic has recently been called into question (see "How many people really died in the Black Death?" page 50).

Nor was it the last. The little-known third plague pandemic started in 1772 in the Chinese province of Yunnan, reached Hong Kong in 1894 and from there spread around the world on steamboats and locomotives, killing about 20 million people. All told, the plague is estimated to have caused the deaths of 200 million people.

The third pandemic eventually petered out in the 1940s, but the bacterium that caused it didn't go away. "We talk about the three major pandemics, but we have to remember that there's an ongoing issue," says Jason Rosenzweig at Texas Southern University in Houston. "I think it's going to become more of a problem in the future."

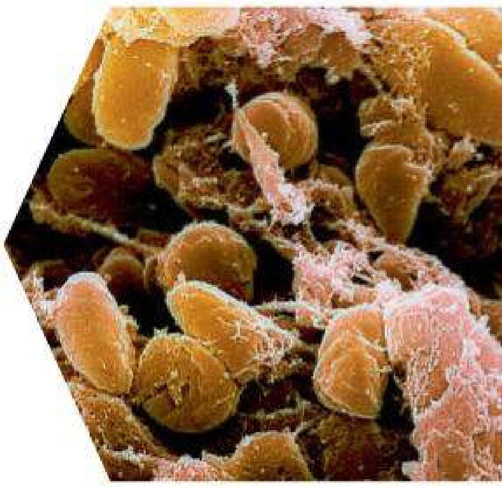
The ongoing issue is that, every now and then, plague breaks cover and kills people. The bacterium that causes it, *Yersinia pestis*, constantly circulates in rodents – rats, mice, marmots, gerbils, ground squirrels and the like – and their blood-sucking parasites. These flea-bitten hordes form what are known as "zoonotic reservoirs" that are abundant and widespread and hence considered impossible to eradicate.

Today, there are reservoirs on every continent except Australia. And whenever humans come into contact with them, there is a risk of plague jumping ship, either through direct contact with infected mammals or, more often, their fleas.

Sporadic cases of plague are surprisingly common, and can sometimes spark an epidemic, as was the case in Madagascar in 2017. This epidemic seems to have started when an infected man got on a bus in the country's central highlands and travelled to the eastern city of Toamasina via the capital Antananarivo. He infected dozens of fellow passengers before dying in transit. By the time the outbreak fizzled out, 2348 people had been infected and 202 of them had died. There have also been recent outbreaks in India, China and the US, and a general pattern of ever-increasing cases worldwide, according to Rosenzweig's collaborator Ashok Chopra at the University of Texas Medical Branch in Galveston.

Plague is now considered a re-emerging disease. One reason for that is our relentless encroachment on nature, which, as we found to our cost with covid-19, brings us into ever more regular encounters with animals carrying pathogens. "The human population continues to grow and as we continue to develop previously underdeveloped or completely untouched lands, we come into closer contact with these zoonotic reservoirs," says Rosenzweig.

The bacteria that causes plague, *Yersinia pestis*



NIAID/CDC/SCIENCE PHOTO LIBRARY

Once a human is infected, the disease's progression is rapid, or what doctors call "fulminant". From its entry point, typically a flea bite, the bacterium invades lymph nodes in the groin, armpit or neck and replicates wildly, causing painful swellings called buboes. This is the infamous bubonic plague, which is bad enough: after an incubation period of as little as two days, it causes a sudden attack of fever, chills, headaches, body aches, weakness, nausea and vomiting.

But it can get much worse. From its bubonic base camp, the infection can spread to the bloodstream to become septicaemic plague or to the lungs to develop into the pneumonic form. Septicaemic plague progresses to septicaemia and pneumonic to pneumonia, and from that point there is usually only one outcome. Left untreated, all varieties are highly lethal. If the infection remains bubonic, survival rates can be as high as 70 per cent. But untreated septicaemic and pneumonic plague are almost invariably fatal.

Septicaemic plague recycles the pathogen back into parasites, while pneumonic plague can spread from person to person via infected respiratory droplets inhaled from the air or picked up from surfaces. That is also why outbreaks can spread so rapidly.

All three forms of plague can be cured with antibiotics. But the Madagascan outbreak had a mortality rate of almost 10 per cent, despite more than a million doses of antibiotics being thrown at it. More than 75 per cent of cases were pneumonic, which has a much shorter window for treatment than the bubonic form. If antibiotics aren't initiated within 24 hours of symptoms appearing – which, for pneumonic plague, can be within a day of exposure – the fatality rate is almost 100 per cent. ›

How many people really died in the Black Death?

"What the historians mainly tell us is that half of the people that lived in Europe died due to the Black Death," says Alessia Masi at the Max Planck Institute for the Science of Human History in Jena, Germany, referring to the outbreak of plague in the 14th century caused by the bacterium *Yersinia pestis*. "But it's hard to say if it is true or not." Masi's recent work certainly gives pause for thought.

The 50 per cent figure relies heavily on written records, but these are sparse and mainly from urban areas in a handful of countries – England, France, Italy and the Netherlands. Some cities probably did endure death rates of 50 per cent or more. "For London, the impact was terrible," says Masi. But in the 14th century, only around 10 per cent of people lived in towns and cities. In order to get a full measure of the impact, you have to look at rural populations.

Mortality records for these areas are sparse at best, so Masi and her colleagues turned to pollen. Their hypothesis was that if the plague really did wipe out half of the population, the pollen record would show it. Labour-intensive cereal fields would give way to pasture and, eventually, wild forest as demand for food plummeted, labour shortages bit and agriculture was abandoned. "If a lot of people die, there are not enough people to cultivate the fields, so what we did is to check if there was cereal cultivation before and what happened after," says Masi.

She and her colleagues compiled pollen records from lakes and bogs across Europe dating from 1250 to 1450, roughly a century either side of the Black Death. In some places, the standard narrative of massive mortality stood up. Parts of Scandinavia, France, the Byzantine and Holy Roman empires and the Papal States in what is now Italy all show clear signs of agricultural abandonment. In other places, however, cereal cultivation didn't decline, and in some cases it rose significantly. Castile on the Iberian peninsula, Ireland, Poland and Russia seem to have prospered through the Black Death; rural England shows no signs of decline despite the carnage in London.

Overall, says Masi, "it is not possible that half of the people died". That figure only gained traction in the 19th century, she adds, when historians extrapolated from sparse written records.

Similar claims of exaggerated mortality have been levelled at the first plague pandemic, often known as the Justinianic plague after the Byzantine emperor Justinian I who was on the throne when it broke out in AD 541. From Constantinople, it spread around the Mediterranean and on to northern Europe and the Middle East, finally ending in the mid 8th century. Historical sources suggest that its mortality rate was 25 to 50 per cent, and that the cataclysm helped to bring down Roman civilisation, ushering in the so-called Dark Ages.

An allegorical representation of the plague from 1540

SCIENCE HISTORY IMAGES/ALAMY

Y. pestis was certainly in the right place at the right time: its DNA has been isolated from dozens of skeletons from the afflicted areas. However, Lee Mordechai at the Hebrew University of Jerusalem in Israel says there is scant scientific evidence of a devastating pandemic in the 6th to 8th centuries. "We looked at all the data sets that we would expect to find plague, or some signal of plague, in them and we were not able to see that."

Pollen records again show no sign of agricultural abandonment. There is no increase in mass burials, no disruption to coin production and no chronicle of an unfolding catastrophe in written records. Tens of thousands of Egyptian papyri from the years when the plague was supposedly raging there, for example, don't mention it at all.

All told, the record suggests that, though Constantinople was probably devastated by the first wave and there may have been other local high-mortality outbreaks, there was no pandemic, says Mordechai. Masi and her team also have pollen data from the first pandemic and will publish their own analysis in due course. "It's difficult to see how such a massive event that kills half of all the people would not find more discussion in historical sources," says Mordechai.

Plague can jump to humans through rats and their parasites

ANATOLY PAREEV/GETTY IMAGES

> **"There is also the diabolical prospect of *Y. pestis* acquiring antibiotic resistance"**

In a place like rural Madagascar, access to treatment is often limited. But higher-income nations can't rest on their laurels. In 2015, 15 people caught plague in the US. Four died, a mortality rate of more than 25 per cent.

There is also the diabolical prospect of *Y. pestis* acquiring antibiotic resistance, which would render our best treatments useless. It could gain that resistance from other bacteria through a process called horizontal gene transfer, which is probably how it evolved its lethal virulence in the first place when it diverged from the much less dangerous stomach bug *Yersinia pseudotuberculosis*. This is a theoretical threat posed by all bacterial pathogens and a very real one when it comes to plague. Resistance to various antibiotics has been observed in *Y. pestis* samples taken from wild animals, and bacteria isolated from infected people have shown resistance to every drug recommended for treatment. "Most infections are still fairly treatable, but if a drug-resistant strain becomes an issue, not just locally but even globally, that scenario could potentially be grim," says Rosenzweig.

Another frightening possibility is that plague could be turned into a bioweapon. Alongside anthrax, *Y. pestis* is considered the most readily weaponisable human pathogen, says Rosenzweig.

Given these threats, by far the best option is vaccination. Existing vaccines have proven effective in the past, but they are showing their age. In 2018, the World Health Organization (WHO) said it no longer recommended immunisation with these old vaccines.

Vaccine push

The most widely used were "live attenuated" vaccines, based on a living strain of *Y. pestis* rendered harmless by mutations but still capable of provoking an immune response. The first was developed from a bacterium isolated from a Malagasy child who died of plague in 1926, and first used in Madagascar in 1934.

It was later distributed to other countries on the front line of the third plague pandemic, including China, Brazil and the USSR. Another vaccine used in this pandemic consisted of corpses of *Y. pestis* killed by formaldehyde. These vaccines probably saved tens of millions of lives and helped to halt the pandemic, says Andrey Anisimov at the State Research Center for Applied Microbiology and Biotechnology in Obolensk, Russia.

However, they have major drawbacks. The killed vaccine produces only short-lived immunity and is ineffective against pneumonic plague. The attenuated vaccines can lead to side effects including rashes, inflammation and abscesses, and there is the ever-present danger of reversion, where the bacterium remutates back to its virulent form. That hasn't happened yet, but in 2009 a researcher died of septicaemic plague in Chicago after coming into contact with an attenuated strain in the lab. He turned out to have a genetic condition that essentially rearmed the bacterium, but the condition is common enough in white people that some researchers have said attenuated vaccines are too risky for this ethnic group.

After the 2017 Madagascan outbreak, the WHO said there was an urgent need to develop new plague vaccines. There are now more than 20 in the pipeline. Rosenzweig is part of a group working on better attenuated vaccines and an adenovirus-based vaccine using technology similar to the Oxford/AstraZeneca covid-19 jab, while Anisimov's group is developing a "bacterial ghost" vaccine, which consists of the bacterial cell wall emptied of its contents. Other teams are also exploring various vaccine technologies, including edible vaccines designed to suppress the rodent reservoirs. But none has yet fulfilled the WHO's criteria for a successful vaccine.

Progress is slow. "Funds are limited; resources are limited," says Rosenzweig. "Like other pathogens that could become an issue, pestis is not a pressing issue all the time. It breaks onto the scene, does some damage, scares people, disappears, and then people tend to forget about it."

We would do well to remember. The next pandemic might be another novel zoonotic virus – or it might be an old foe resurgent. The world is unlikely to endure a cataclysm on the scale of the Black Death again, and yet it is worth bearing in mind that even with vaccines and antibiotics at our disposal, plague still kills 10 per cent of the people it infects. For comparison, the prevaccine death rate from covid-19 was just 1 per cent, and that brought entire countries to a standstill. So if plague does get even more deadly, all bets are off, says Rosenzweig. "You have to prepare for the worst." ■

Graham Lawton is a features writer at *New Scientist* and author of *Mustn't Grumble*

Puzzles
Try our crossword, quick quiz and logic puzzle p53

***Almost* the last word**
Do our beliefs give us an evolutionary advantage? p54

Tom Gauld for *New Scientist*
A cartoonist's take on the world p55

Feedback
Elon Musk and Twitter bots: the week in weird p56

Twisteddoodles for *New Scientist*
Picturing the lighter side of life p56

Science of gardening

Put your soil to the acid test

Finding out your soil type means you can choose the plants that suit it and maximise their chances of thriving, says **Clare Wilson**

Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

A soil pH test
A lump of soil

HAVE you ever wondered why some plants in your garden thrive, while others barely grow no matter how tenderly they are nurtured? It may not come down to your green fingers, but to whether you have chosen the right plant for that spot.

Most people know they need to consider their local climate and how much sunshine any particular site gets. But you should also choose the right plant for your soil type, which depends on your area's geology and history. You can find maps of soil type online, but gardens can differ at a local level.

A first step is to find out the soil pH, or how acidic or alkaline it is. You can buy simple test kits that enable you to scoop a small quantity of soil, mix it with a chemical and compare the resultant liquid to a colour chart. Most soils in the UK are neutral or very slightly acidic, and this allows a wide range of plants to grow.

If your soil is especially acidic or alkaline, you could theoretically change it by adding lime or iron sulphate respectively. But it is easier to just buy plants that suit your soil pH, and to use pots or raised beds if you have any favourite plants that need different conditions.

My own garden soil is slightly acidic, which may explain why alkaline-loving lavender plants have never done well there. I love azalea bushes for their gorgeous spring flowers, but they need even more acidic soil, so I grow them in pots of special compost.

BLICKWINKEL/ALAMY

Another factor that affects plant health is the size of the soil particles. Smaller grains, known as clay, hold more water, which can lead to plant roots getting waterlogged and means that the soil is harder to dig. Larger particles are called sand, and medium ones are called silt. Sandy soils are free-draining, but they can be less fertile since nutrients will get washed away much more easily.

While most soils have a mixture of particle sizes, you can find out which one predominates in your garden if you don't mind getting your hands dirty.

Take a handful of soil, wet it and see whether you can form a ball, a sausage, a horseshoe or a ring without breaking it. The more mouldable the soil is, the more clay particles it contains.

You could also find out how many earthworms are in your soil, a good sign of its fertility, or even how compacted it is. But just knowing the pH and texture of your soil is probably enough when it comes to choosing plants. That said, nearly all types of garden soil will be improved by adding lashings of organic matter, such as home-made compost or well-rotted animal manure.

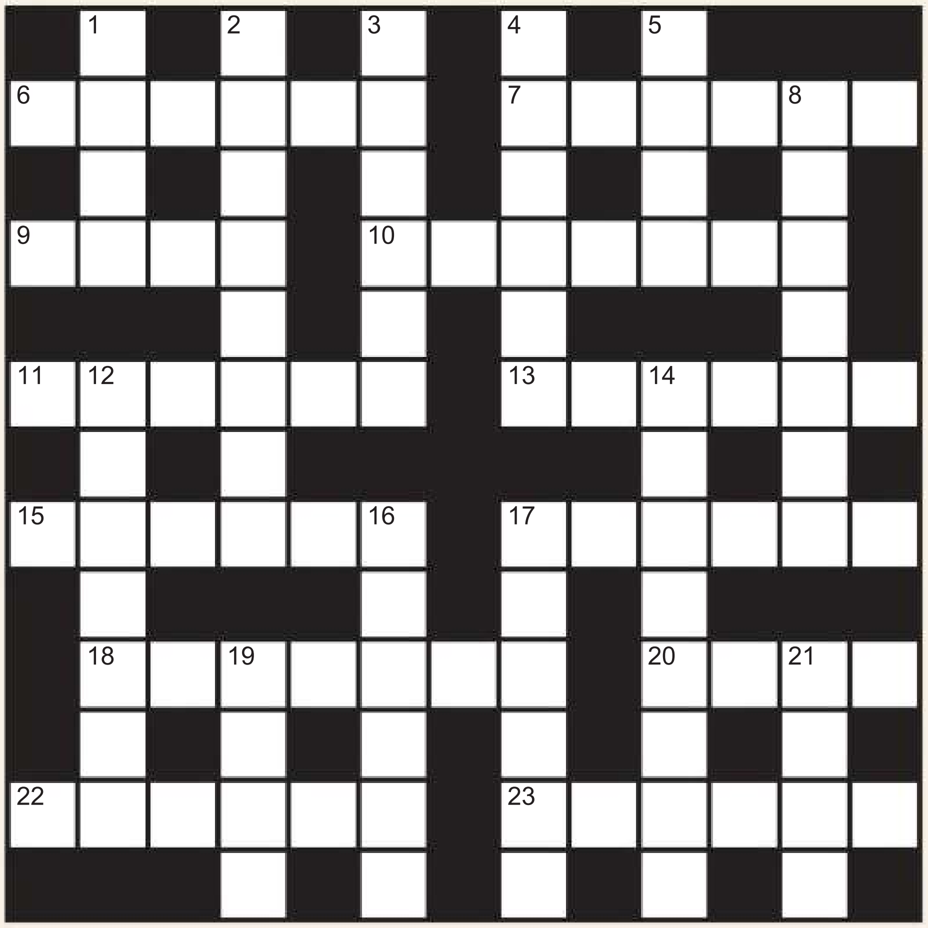
If this seems like too much work, a simple rule of thumb is to see which plants are growing well in your neighbours' gardens. After all, imitation is the sincerest form of flattery. ▮

Science of gardening appears every four weeks

Next week
Citizen science

These articles are posted each week at newscientist.com/maker

Cryptic crossword #84 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

6 Whiten sand surrounding lake (6)
7 Quirky nurse beginning to temper troubled state (6)
9 Bathed throats the wrong way (4)
10 Taking time out, contemplate referee (7)
11 Pampering excursion, for example, involving cushion (3,3)
13 Eager type vacated cell (6)
15 Cleaning tool twice repelled decorative fluff (3-3)
17 Stabilising device corrected IBM lag (6)
18 With leaders of Venezuela and Suriname swapping places, monitor the Queen's side (7)
20 Silent signal with electronic standing wave feature (4)
22 Posing as royalty (6)
23 Rush second takeaway order (6)

DOWN

1 Radiance increase making radius large (4)
2 Blocked distinguished woman hoarding last of rum and upside-down cake, perhaps (6,2)
3 Child's question about instant message's humour (6)
4 Weird sound accompanies grand optical phenomenon (3,3)
5 A Shakespearean excerpt (4)
8 Colourful bands improved carpets (7)
12 Packets of light Vietnamese soup? Loads (7)
14 Abstract Monet wrapped by parent is something conserved in a collision (8)
16 Illusion of silver in bog (6)
17 Discussed exporter of olive oil lubricant (6)
19 Short YouTube clip includes round vacuum (4)
21 Poorly lit playground getting a new entrance (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #153

1 Tamu Massif and Mauna Loa are examples of which type of volcano, known for its low profile?

2 In what year was the first mobile phone invented?

3 Where in the body would you find the islets of Langerhans?

4 Which spacecraft achieved the first soft landing on the moon?

5 Which of these poisonous mushrooms isn't part of the *Amanita* genus: the death cap, the deadly dapperling or the fool's mushroom?

Answers on page 55

Puzzle

set by Zoe Mensch

#169 A Domino Piazza

Some town squares are designed as giant chessboards, but urban planner Dominica has paved her town's new piazza with giant dominoes instead.

Picking different dominoes at random from a set, she laid them down flat to form a 7x7 square of numbers (pictured, below), leaving one space in the centre for a fountain.

Using the numbers on the diagram, can you draw the outlines of the dominoes that Dominica used, and figure out which dominoes she left out? (Remember that a full set of dominoes contains every pair of numbers from 0-0 to 6-6. There were no duplicates).

3	0	5	5	1	1	1
2	4	6	2	6	3	0
1	4	0	2	5	4	1
0	4	6	⛲	1	0	2
2	3	3	5	0	3	5
0	0	6	2	1	3	5
5	6	1	2	6	6	3

Solution next week

Basis of belief

Humans believe in many things, often with no solid evidence. So does belief give us an evolutionary advantage, or is it just something that survived regardless?

Gerard Buzolic
Coolum Beach,
Queensland, Australia

The ability to believe in what others have discovered or seen provides an advantage. It enables us to work together, or to take the work of others and build on it. The same ability lets us take intellectual shortcuts, bypassing the hard work of gathering and evaluating evidence. Still, the species as a whole benefits.

Let's not forget that some things are intangible. The experience of art, music and beauty is hard to prove with solid evidence, but these things put the reason to survive into life.

Nick Baker
Colchester, Essex, UK

For a social species like humans, there probably is an evolutionary advantage in belief, because working everything out logically from evidence would take too long.

> **"When humans became aware of their mortality, they may have developed the idea of an afterlife as a form of consolation"**

When I take a paracetamol tablet to alleviate toothache, I don't have the evidence that it will work and not poison me, but I believe that this evidence exists. That involves trust.

We trust in our fellow humans' experience, judgement and advice, and this can give us an evolutionary advantage. But it can also lead us astray. What if we believe in something not because we think that evidence exists to support it, but just because we like the sound of it, or we like the unsubstantiated promises that go along with it, or we even see strategic advantages in being seen to believe in it?

Of course, we now have to question our interpretation of evolutionary advantage. Is the present situation, in which the planet is struggling for survival under the dominance of one destructive species, really to be seen as an evolutionary triumph?

Wade Miller-Knight
London, UK

Evolution favours people and societies that hold that their environment is understandable and makes sense, because this facilitates useful decision-making.

When an experience doesn't "make sense" as understood by a society, belief in luck, spirits, a customary practice, magic, chance and so on enables sense to nevertheless be made of that experience.

Francis Blake
London, UK

The person who posed this question doesn't specify belief in anything in particular, though I wonder if they had religion, or other supernatural beliefs, in mind?

When humans first became aware of their mortality – that is, of the inevitability of death – they may well have developed an idea of some sort of survival, perhaps an afterlife, as a form of consolation to avoid the bleak prospect of mere oblivion.

That would tend to make any present misery more bearable. You might expect the tendency towards such beliefs to be gene encoded eventually. This would account for the fact that almost all cultures (though not all individuals) support some form of supernatural belief.

There would be a real advantage in a belief that added purpose – or seemed to do so – to an otherwise harsh life, even if such belief wasn't really supported with hard evidence.

JUPITERIMAGES/GETTY IMAGES

How does the complexity of Earth's biosphere compare to that of the human brain?

This week's new questions

Complexity conundrum **It is often stated that the human brain is the most complex object in the universe, but is it more complex than, say, Earth's biosphere? And how can this complexity be measured?** ***David Northrop****, Exeter, Devon, UK*

Up in flames **What shape would a candle's flame be in zero gravity?** ***Richard Deverell****, London, UK*

Magnetic weather

Does Earth's magnetic field affect the weather?

Mike Follows
Sutton Coldfield,
West Midlands, UK

The jury is still out, but the verdict is likely to be that there is no causal link between Earth's magnetic field and our weather.

A possible link was suggested by Danish physicist Henrik Svensmark in his galactic cosmic ray hypothesis. This proposes that protons in cosmic rays blasted out by exploding stars called supernovae collide with our atmosphere. According to the hypothesis, this creates condensation nuclei, leading to cloudier skies, colder weather and a cooler climate.

When the magnetic fields of the sun or Earth are strong, there is greater deflection of the charged particles of galactic cosmic rays, so there should be fewer clouds and the weather and climate should be warmer. Conversely, when the magnetic fields are weaker, the prevailing weather should be cloudier and colder.

Evidence that appears to support this hypothesis comes from the so-called Maunder Minimum, which occurred between 1645 and 1715. During this period, the sun had fewer sunspots – cooler, darker areas on its surface. This happens when the

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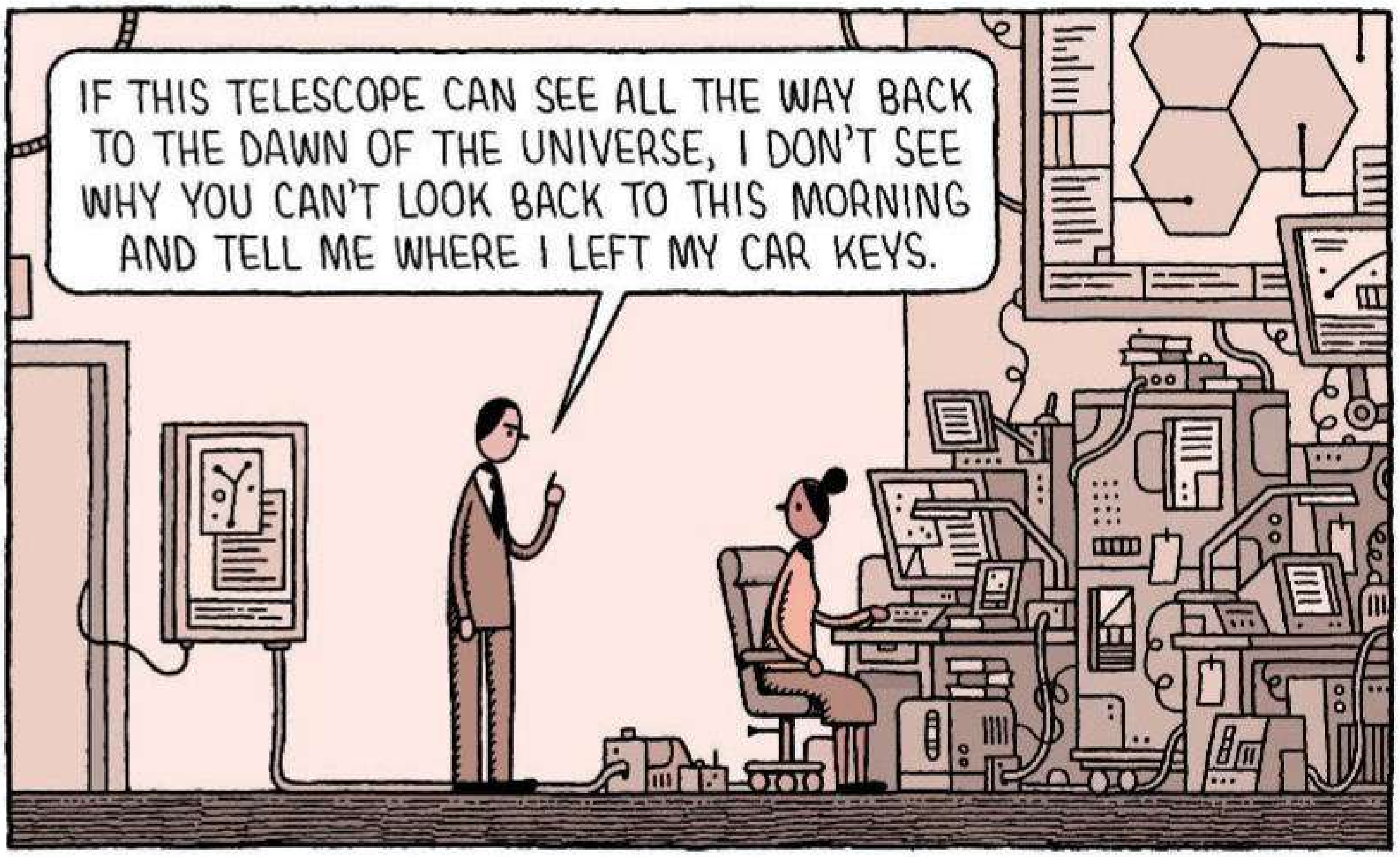
Tom Gauld
for New Scientist


IF THIS TELESCOPE CAN SEE ALL THE WAY BACK TO THE DAWN OF THE UNIVERSE, I DON'T SEE WHY YOU CAN'T LOOK BACK TO THIS MORNING AND TELL ME WHERE I LEFT MY CAR KEYS.

sun's magnetic field is weaker, so at that time there was less deflection of cosmic rays in the solar system and hence, if Svensmark is correct, cloudier and colder weather on Earth.

At the same time as the Maunder Minimum, Europe was enduring the Little Ice Age, in which temperatures fell low enough for "frost fairs" to be held on the river Thames.

This possible link between galactic cosmic rays and cloud formation is being tested at the CERN particle physics lab near Geneva, Switzerland. There, the Proton Synchrotron is being used to produce high-energy protons to mimic galactic cosmic rays. These are being fired at the CLOUD experiment, which is basically a chamber of very clean air. The fact that there are other sources of condensation nuclei complicates the picture, and so far, the results of the tests aren't clear-cut.

Svensmark's hypothesis is elegant, but, to paraphrase Thomas Huxley, "many a beautiful theory was killed by an ugly fact".

> **"When the magnetic fields of the sun or Earth are strong, they deflect the charged particles of galactic cosmic rays"**

Impending doom

Do any animals, other than us, have an awareness of their own mortality? (continued)

Paul Wolf
Arundel, Maine, US
The question is backwards. What proof do we have that other animals aren't aware of mortality? In the absence of such proof, it should be assumed they are, since the only animal we have insight into (humans) clearly is aware of its mortality. Assuming other animals don't have this awareness is a presumption of human chauvinism – that we are somehow special and different from other animals.

Increasingly, research and observations of animal intelligence show that we may not be so different.

Dudley Dean
Maresfield, East Sussex, UK
A long time ago, we had two dogs, a castrated male and female, who were very attached to each other. He died and she became upset. She wouldn't leave her bed, eat or sleep. There was no question that she knew this separation was different and much more serious than normal ones.

We have known dogs that were very distraught at the death of their owner, whereas a holiday separation didn't affect them. Elephants also clearly know that death is much more serious than other types of absence.

It is obvious to me that some of the more intelligent animals are certainly aware that death is a permanent separation. It is, however, impossible to know whether they are aware that they will die. We won't know unless one day we learn to communicate with these animals much better than we can now. ▮

Answers

Quick quiz #153
Answers

1 Shield volcano
2 1973
3 The pancreas
4 Luna 9, in 1966
5 The deadly dapperling (*Lepiota brunneoincarnata*)

Quick Crossword #108 *Answers*

ACROSS 1 Immunoglobulin, **10** Umami, **11** Soil creep, **12** Roe deer, **13** Glushko, **14** Seton, **16** Gastritis, **19** Serotonin, **20** Latex, **22** Boobies, **25** Cattail, **27** Hashimoto, **28** Rails, **29** Patent medicine

DOWN 2 Meat eater, **3** Urine, **4** Oestrogen, **5** Laing, **6** Becquerel, **7** Leech, **8** Nap pods, **9** Quarks, **15** Nutrition, **17** Sand Cloud, **18** Titration, **19** Sibship, **21** Xylose, **23** Onset, **24** Storm, **26** Toric

#168 Bone Idle
Solution

Rick has to revise at least 11 topics. To figure out how many topics you need to study, imagine the worst-case scenario. In this palaeontology exam, the maximum number of topics that you could revise, only to find that none come up in the exam, is seven (18 topics minus 11 questions). So if Rick revises seven subjects, plus an additional four, then he will have at least four questions to choose from.

In general, if there are T topics, X exam questions and Q questions to be answered, then to be certain that at least Q of your topics will come up, the minimum number of topics N that a lazy student should revise is given by $N = T - X + Q$.

Emissions cuts

Feedback's recent item on the Royal Institute of Philosophy's journal pondering the metaphysics of farting – "Is it a thing or an action?" being the chief question – has drawn short shrift from reader Guy Cox. He believes the author should have used that essential method of philosophical inquiry known as "looking it up in a dictionary". Cox also points out that the subject has previously been expounded on by no less a personage than US writer, inventor and all-round genius Benjamin Franklin.

Franklin wrote an entire essay urging his fellow natural philosophers to investigate whether they could develop food additives to make humanity's gaseous emissions less malodorous. It must be possible, he reasoned, because we know their smell can be affected by variations in diet. "He that dines on stale Flesh, especially with much Addition of Onions, shall be able to afford a Stink that no Company can tolerate; while he that has lived for some Time on Vegetables only, shall have Breath so pure as to be insensible to the most delicate Noses; and if he can manage so as to avoid the Report, he may any where give Vent to his Griefs, unnoticed." Indeed.

Franklin turns out to be keen on people giving Vent to their Griefs unimpeded by concerns about the odour. Many readers may empathise. Who among us hasn't at times tried to give Vent to their Griefs, unnoticed?

Gas bags

Franklin wrote the essay – now commonly known as "Fart Proudly" – in response to a call for papers from the Royal Academy of Brussels. He wanted to prick the pomposity of the scientific societies of Europe, which he believed had become too pretentious and concerned with impractical matters.

Now the context is clear, some sections of the essay make more sense, such as when Franklin compares the physical comfort of passing wind to the intellectual satisfaction of understanding the latest science – like seeing white light split up into seven colours by a prism. Franklin is trolling the European royal societies. Feedback likes him more by the minute.

Twisteddoodles *for New Scientist*

I SPENT THREE HOURS OBSERVING THE BIRDS THROUGH THE WINDOW AND THESE ARE MY FINDINGS
KA KA KA KA KA KA KA KA KA KA KA KA
@twisteddoodles

Got a story for Feedback?

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Consideration of items sent in the post will be delayed

Bot or not

The tech world has lately been kept rapt by the saga of Elon Musk's quest to buy Twitter. For those readers unfamiliar with Twitter... you are advised to keep it that way. The service is described as the modern world's town square, although a better description might be a mash-up of a debating chamber, playground and barroom brawl.

Something about being on Twitter encourages many users to express themselves in language that is uniquely artificial, sanctimonious and finger-wagging. Those who have transgressed in some way are told to "Do better" and there is an inexplicable fondness for stressing points by punctuating each word with a handclap. It would seem odd if we spoke to each other this way in real life. "You haven't done the washing up. Do better." "No 👏 way 👏 I 👏 did 👏 it 👏 yesterday 👏".

Musk himself tweets prolifically, most of the time, he admits, while sat on the toilet – and now he seems to want to buy Twitter. He says its moderation policy is jeopardising free speech and he also wants to get rid of bots, computer programs that churn out automated tweets.

Last week, Musk said the deal can't progress without proof that no more than 5 per cent of users are bots. The service's owner says that is impossible. In the firm's defence, a program that analyses tweets to gauge if there is a human behind them concludes that Musk himself may well be a bot. In fact, he scored a higher chance of being one than @ElonJet, an acknowledged bot account that tweets Musk's travels using flight-tracking data for his jet. As one user says: "Musk being a robot would be such a great twist."

Crypto crunch

It pains Feedback to return to the subject of cryptocurrencies, but we have no choice given recent events. This magazine's tech correspondent has tried to explain how they work to Feedback many times, and swears that some cryptocurrencies could be a force for economic good. But our colleague admits that the price volatility of many of the newer ones are reminiscent of speculation bubbles such as those around tulip bulbs in the 17th century and a certain South Sea Company the following century.

One of the UK's biggest crypto fans is former health minister Matt Hancock, last seen resigning for having an affair while the country was supposed to be social distancing. "I want the UK to love crypto. We've got to be on the side of the future," says Hancock in a recent interview, although should we really take tech advice from someone who thought the perfect spot for an illicit snog was in front of a government security camera?

Hancock is keen to promote a type of cryptocurrency called stablecoins, which he says are more reliable. The article barely mentions that the crypto market has been falling since November, with several stablecoins plunging in value in recent weeks.

But we still haven't yet come to the really big crypto news: nominative determinism. Reader Barney Herring points out that the founder of Bahama-based cryptocurrency exchange FTX, who reportedly lost half his net worth this year, is called Sam Bankman-Fried. Investors who got their fingers burned can't say they had no warning. ▮

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